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# THE JUNE SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

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THE SCIENTIFIC MONTHLY

JUNE, 1926

# THE STORY OF YALE'S GREAT MUSEUM

By ROLLIN LYNDE HARTT

An embarrassed young man, booked as Benjamin Silliman, Esq., boarded the stagecoach at New Haven one day in the winter of 1801–2. He was doubly embarrassed. Not only had Yale made him its professor of chemistry and natural history, sciences in which he could not yet claim proficiency, but he carried with him an exceedingly awkward candle-box, whose aspect aroused the curiosity of his fellow-travelers.

The candle-box contained Yale's entire mineralogical collection—and young Professor Silliman was on his way to Philadelphia, where dwelt Dr. Adam Seybert, then the sole American capable of telling authoritatively what the specimens were.

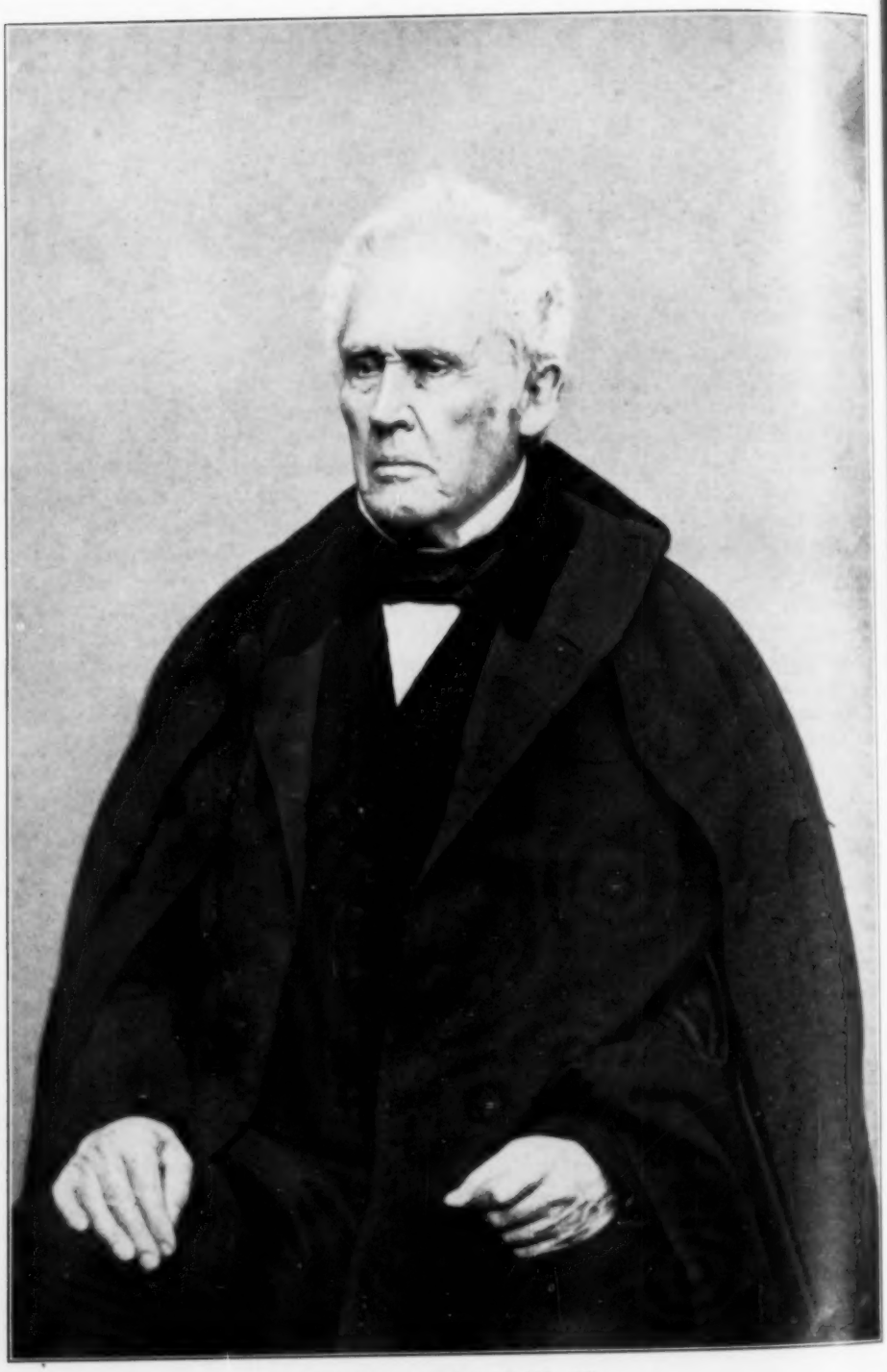
The visit to Seybert appears to have been fruitful, for Silliman returned to New Haven with Yale's possessions nicely ticketed and assumed his professorial duties fairly confidently. Not long thereafter, his brother presented the college with a few minerals brought from England. Then Silliman himself went abroad and fetched home a few more.

Such were the beginnings of what are now the famous collections of the Peabody Museum of Natural History at Yale—humble beginnings, but beginnings very encouraging to Silliman, who wrote, "All these things, when arranged and labelled, served to awaken an interest in the subject of mineralogy, and produced both aspirations and hopes, looking towards a collection which should by and by deserve the name of a cabinet."

Though a thousand dollars represented a serious sum in those days, Yale backed up Silliman in 1807 by expending that amount in acquiring the Perkins collection of minerals, and the professor installed it in his den. "Soon the news of the arrival of this cabinet was spread abroad," he wrote, "and my chamber was visited by many persons, ladies and gentlemen. Some were intelligent, and appreciated the cabinet in relation to science, and all were curious to see beautiful things."

An indiscriminate welcome awaited them, one learns, and most unorthodox it was. In London, not many years before, the Dodsleys had published a guide to "The General Contents of the British Museum" and its author remarked:

> Some of my readers may be ignorant of the Manner of applying to see the Museum; for their Information I shall add, that fifteen Persons are allowed to view it in one Company; the Time allotted is Two Hours; and when any Number not exceeding fifteen are inclined to see it, they must send a list of their Christian and Sir-names, Additions, and Places of Abode, to the Porter's Lodge, in order to their being entered in the Book; in a few days the respective Tickets will be made out, specifying the Day and Hour in which they are to come, which on being sent for, are delivered. If by any Accident some of the Parties are prevented from coming, it is proper they send their Tickets back to the Lodge, as no body can be admitted



BENJAMIN SILLIMAN, SR.

PROFESSOR OF CHEMISTRY AND NATURAL HISTORY AT YALE FROM 1805 TO 1855

SOUTH MIDDLE, NOW CONNECTICUT HALL

IN TWO ROOMS IN THE SECOND STORY THE GIBBS CABINET WAS INSTALLED IN 1807 BY PROFESSOR SILLIMAN.

with it but themselves. It is to be remarked that the fewer Names there are in a List, the sooner they are likely to be admitted to see it.

Yale's first really important acquisition fell literally from the skies. A huge meteor, said by eye-witnesses to have been two thirds as large as the full moon, exploded over the town of Weston, Connecticut, with a noise like that of a great cannon, and showered the earth with fragments. Taking along Professor Kingsley, Silliman rushed to Weston, which is only twenty-five miles from New Haven, and spent several days picking up the pieces, one of which weighed thirty-six pounds.

This was in 1807, a few months after the acquisition of the Perkins cabinet. Three years later came an event still more thrilling. Colonel Gibbs, of Newport, R. I., had brought over a collection of minerals from England and now offered to loan it to Yale. On behalf of the college, President Dwight accepted, and in 1812 the Gibbs Cabinet was installed in two rooms let together in the second story of South Middle, now known as Connecticut Hall. At last, a museum! Forty feet, one way! Eighteen the other! Popular excitement ran high.

Long afterward Professor E. S. Dana wrote:

It is, perhaps, not easy for us, at the present time, to appreciate the profound impression which the collection made upon the visitors who came from far and near to see it. It was a time when scientific collections were few, and when specimens from Europe were rarely seen.

BENJAMIN SILLIMAN, JR.
TEACHER AND PROFESSOR OF CHEMISTRY AT YALE FROM 1837 TO 1885

In Silliman's own account of the Gibbs Cabinet, we read:

> It presented a rich and beautiful sight. The fame of this cabinet was now blazoned through the land. . . . It kindled the enthusiasm of the students, and excited the admiration of intelligent strangers. . . . It was visited by many travellers, and New Haven was then a focus of travel between north and south. Railroads were unknown, and navigation by steam had hardly begun. The comparatively slow-moving coaches conveyed the passengers, who were generally willing to pass a little time in New Haven; and the cabinet of Colonel Gibbs afforded a powerful attraction, while it afforded also a high gratification. . . . Trains of ladies graced this hall of science; and thus mute and animate nature acted in unison in making the cabinet a delightful resort.

For eight years this had continued, when in 1820 the cabinet was removed to the upper story of the then new building called the cabinet. There it seems still to have been a reigning attraction, for Colonel Gibbs's offer to sell it to Yale caused the wildest excitement five years later. Twenty thousand dollars was the price—a staggering sum!

Yale rose to the occasion magnificently, and began what was perhaps the first "drive" ever organized. With mass meetings, with pulpit appeals, and with a house-to-house canvass, New Haven "went over the top," and the renowned Gibbs Cabinet was purchased.

Then for a long time—more than sixty years, in fact—the museum pegged along rather uneventfully, enlarging its collections but experiencing few thrills of the first order. It was dur-

JAMES D. DANA
PROFESSOR OF GEOLOGY AT YALE FROM 1850 TO 1893

ing this period that the Baron Lederer collection was bought for $3,000, and numerous specimens added by Silliman and the elder Dana. Only one highly dramatic event occurred—the snatching of the Gibbs meteorite from the very verge of the grave and its presentation to Yale. In his account of the affair, Professor E. S. Dana tells us:

> This great mass of meteoric iron weighs about three-fourths of a ton (1,635 pounds) and ranks as one of the three or four largest masses ever placed in a scientific museum. It was brought in 1810 to New Orleans from the Red River region in Texas, the belief being that it was a mass of platinum. From New Orleans it was shipped to New York; but the extravagant expectations as to its commercial value were not realized, and it was finally bought by Colonel Gibbs for $500. He presented it, in trust, to the museum of the Lyceum of Natural History in New York. On the removal of the Lyceum from the Park, it was left at the doorway, apparently forgotten. Mrs. Gibbs, the widow of Colonel Gibbs, happening to pass the spot one day, saw some workmen in the act of burying the iron in a hole they had dug for the purpose "to put it out of the way." She rescued it from its threatened burial, and sent it to New Haven, presenting it to the College in memory of her husband.

It was not until 1866 that the growing museum caught the attention of an "angel" and came into a fortune, the gift of George Peabody, an expatriated

OTHNIEL CHARLES MARSH

PROFESSOR OF PALEONTOLOGY, THROUGH WHOSE EXPLORATIONS THE GREAT COLLECTIONS OF VERTEBRATE FOSSILS OF THE PEABODY MUSEUM WERE OBTAINED. MARSH WAS A NEPHEW OF GEORGE PEABODY.

THE FIRST PEABODY MUSEUM

ERECTED IN 1874 AND TORN DOWN SEVEN YEARS AGO TO MAKE ROOM FOR THE MEMORIAL QUADRANGLE.

American who had become a merchant, banker and celebrated philanthropist in London. An old number of the *Critic*, issued just after the Peabody centenary in 1895, contains a sketch of his career as a giver. All told, his varied benefactions amounted to about $12,000,000, and the writer, while confessing that to obtain a complete list of them would be impossible, informs us:

> In 1852 he contributed to the fitting up of Dr. Kane's Arctic Expedition and founded the Peabody Institute, endowing it subsequently with $200,000. To the Baltimore Institute of Science, Literature and Art he gave $1,000,000; in 1862, he established a fund of $2,000,000 for the building of lodging-houses for the London poor. This fund has been increased by judicious management to $5,470,000. In 1866 he gave $150,000 to Harvard for its Peabody Museum and Professorship, and an equal sum to Yale for a department of physical science. He established a Southern educational fund of $2,100,000 for the erection of common schools; founded the Peabody Academy of Science at Salem, Mass., in 1867, endowing it with $140,000, and presented $60,000 to Washington College, Va.; $50,000 to the Peabody Institute of North Danvers; $30,000 to Phillips Academy, Andover; $25,000 to Kenyon College, Gambier, Ohio, and $20,000 to the Maryland Historical Society. He endowed, also, an art-school in Rome.

Although it may be considered a great liberty to criticize the *Critic*, "a department of physical science" was certainly a most inadequate designation of what Peabody brought into being at Yale. What he actually brought into being was the Peabody Museum of Natural History at Elm and High Streets. One wing of the museum was erected in 1874, and the *Yale Courant* observed: "The building, when completed, will not only be the largest but also the most imposing and important in the city. It is to be for the use of all departments of

EDWARD WARD BEECHER

PROFESSOR OF INVERTEBRATE PALEONTOLOGY UNTIL HIS DEATH IN 1904.

the university alike, and will be, like the Art School, a fountain of instruction and entertainment to the public of New Haven. The generous donor has by this gift written his name indelibly upon the memories and hearts of all connected with Yale College, and has done a noble work for natural science." The building was never completed. Mr. Peabody died three years after his gift to Yale and never saw even the one wing.

As the museum found in Peabody its angel, so in Othniel Charles Marsh, Peabody's nephew, it found its most celebrated champion and servitor. Marsh, who had been the first to interest Pea-

body in the scientific movement at Yale, was born in Lockport, N. Y., and the Yale necrologist tells us:

His early advantages were limited, but in 1857 his uncle offered him a higher education and he began his preparation at Phillips Academy, Andover, Mass. Before he entered Yale his scientific bent was already manifest, and he had even begun in a modest way his career as an explorer and discoverer. For two years after graduation he pursued the study of natural science in New Haven, and then spent several years in close study in Germany. In the meantime he had contributed several papers to the *American Journal of Science*, and as early as 1863 his ability had been recognized by his election as a Fellow of the Geological Society of London. On his return from London, he was elected Professor of Paleontology at Yale. Professor Marsh was appointed Curator of the Geological Collections of the College in 1867, and under his superintendence the first wing of the Museum was completed.

A born explorer, Marsh saw in his new position an incentive not only to enrich the museum with new acquisitions but to enrich science itself with new discoveries. Writing of him in Kingsley's "Yale College," George Bird Grinnell says:

After having spent several years in bringing together, from the Cretaceous and Tertiary of the Atlantic coast, a very considerable mass of material, he came to the conclusion that this field was essentially exhausted, and that it was to the West, to the unexplored territory beyond the Missouri River, that the paleontologist must look for the facts which would lead him to an intelligent comprehension of the progress of vertebrate life in the past. This conclusion was confirmed by his own observations made during a short trip to the Rocky Mountains in 1868, during which he obtained much information, which proved of the greatest value in his subsequent visits.

Accordingly, in 1870, the first of the Yale Scientific Expeditions was organized, and, after spending five months in the field, returned well laden with fossil treasures from the Cretaceous and Tertiary formations. The success of this experiment was so marked that the four succeeding years witnessed the departure of as many expeditions, all of which were successful, and the results may be briefly summed up in the statement that, altogether, within six years from the time that the first one started out, these expeditions under Professor Marsh had brought to light no less than four hundred species of vertebrate fossils new to science. At the time these explorations began, the far West was almost wholly unknown, and the investigators were exposed to great hardships, and to no little danger from hostile Indians.

Professor Richard S. Lull, the museum's present director, relates that "one day with the thermometer at from 110 to 115 the party marched for fourteen hours without water. Another such day would have destroyed half the stock and produced the saddest results among the men." Also, he tells us that though the explorers had a military escort, and were accompanied by Buffalo Bill, "the redskins set the prairie on fire when the party were encamped, and only by the utmost exertion did the latter save themselves and their animals from the flames." One winter they had an Indian escort wished on them under the leadership of Sitting Bull, and Professor Lull tells us:

This escort was ostensibly to guard the party against the Northern Indians, but really to keep watch upon the actions of the bone-hunters. The next day snow fell, delaying the departure. In the meanwhile the annuities were issued, so the Indians were no longer on their good behavior. So hostile a demonstration was made that their departure would probably have precipitated a general mêlée, and the only prudent thing to do was to withdraw. Later another escort was furnished by the Indians.

When the test came, however, the Indians again refused to go. Finally, exasperated by the numerous delays, Professor Marsh decided to evade the Indians, and shortly after midnight the expedition filed as silently as possible between the Indian villages to the only place where the White River could be forded. As they marched by, the Indian dogs barked furiously, but their owners slept. By daylight Indian scouts were riding from village to village giving the alarm, and horsemen were seen posted on the high buttes to watch the party. After a rapid march a strong camp was pitched and the exploration and collecting was carried on in the intense cold as rapidly as possible. Threats of attack by the Northern Indians made the risk of remaining very great, but in spite of it

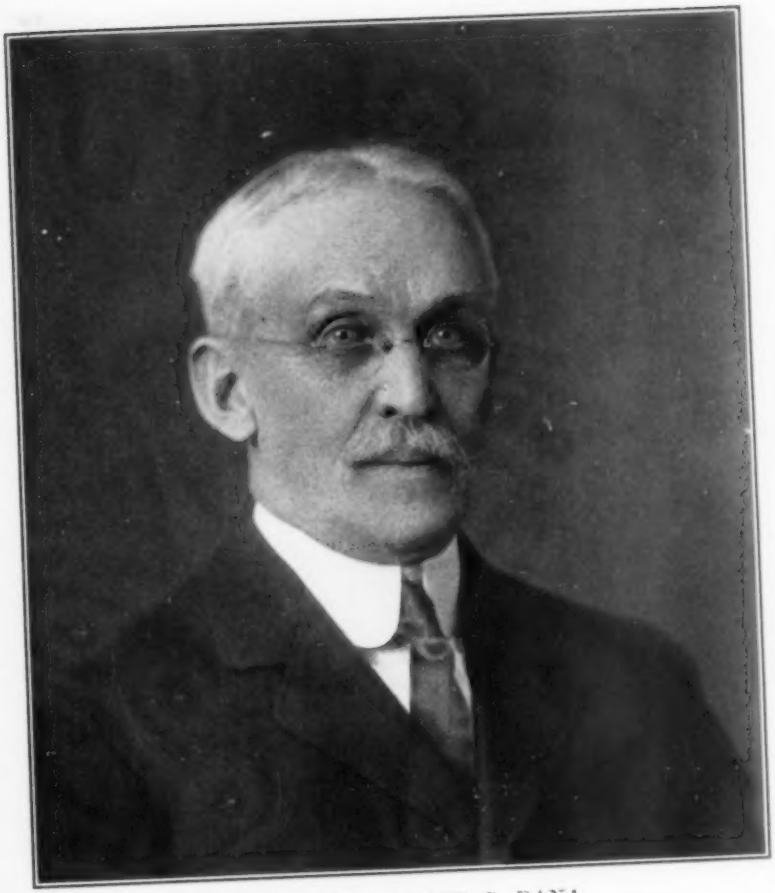
PROFESSOR A. E. VERRILL

PROFESSOR OF ZOOLOGY AND CURATOR OF THE ZOOLOGICAL COLLECTIONS FROM 1864 UNTIL HIS RETIREMENT IN 1907.

sufficient time had to be taken to pack the fossils, which would otherwise have been destroyed in transit. The party retreated, however, none too soon, as a large war party scoured the Bad Lands the next day in a search for the intrepid white "Bone Chief" and his band.

Among the fossils which Marsh brought home from the west were those of toothed birds, very important as illustrating evolution; of the horse and its precursors; of the first pterodactyl ever found in America and the first apes; of giant turtles and giant sloths; of marsupials and bats never before known to have existed here; of birds, serpents, lizards and fish; of the prehistoric rhinoceros; and of amazing dinosaurs. In his letter presenting his collections to Yale in 1898, he said of his vertebrate fossils:

> This is the most important and valuable of all, as it is very extensive, contains a very large number of type specimens, many of them unique, and is widely known from the descriptions already published. In extinct mammals, birds and reptiles, of North America, this series stands preeminent. This collection was pronounced by Huxley, who examined it with care in 1876, to be surpassed by no other in the world. Darwin, in 1878, expressed a strong desire to visit America for the sole purpose of seeing this collection. Since then it has been more than doubled in size and value and still holds



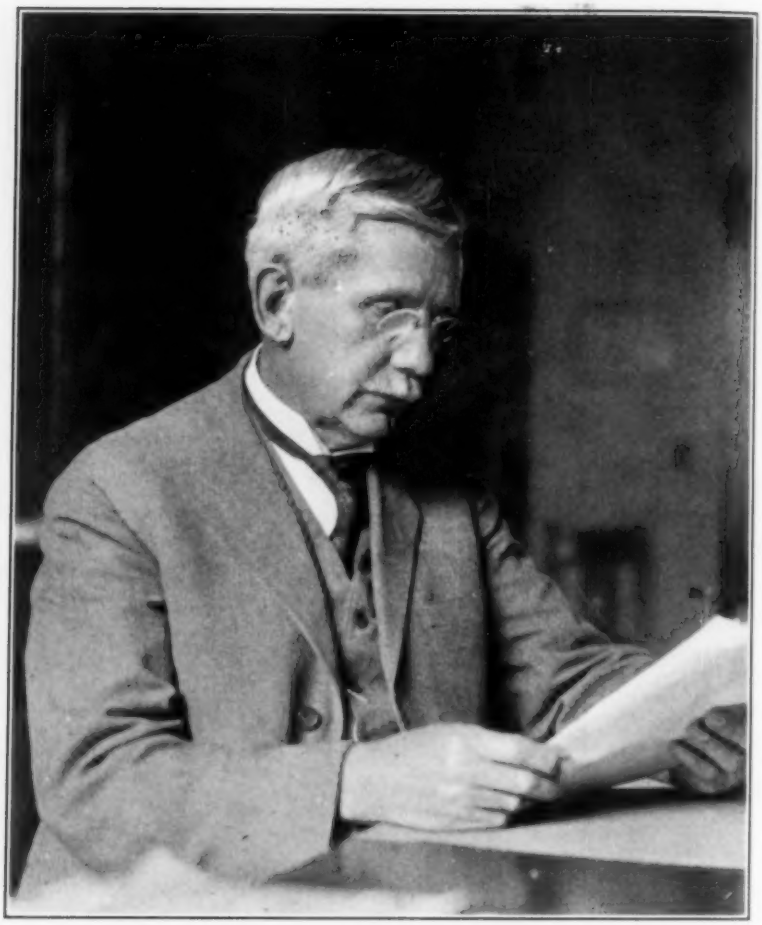
PROFESSOR EDWARD S. DANA

PROFESSOR OF PHYSICS AND CURATOR OF THE MINERALOGICAL COLLECTIONS FROM 1874 UNTIL HIS RETIREMENT TO BECOME PROFESSOR EMERITUS IN 1918; TRUSTEE OF THE PEABODY MUSEUM SINCE 1885; EDITOR OF AMERICAN JOURNAL OF SCIENCE SINCE 1875.

first rank. The bulk of this collection has been secured by my western explorations, which have extended over a period of nearly thirty years, during which I have crossed the Rocky Mountains twenty-seven times.

He might have added that for nearly thirty years he had served without salary and that he had spent upon his collections more than $250,000 of his own money.

Along with the vertebrate fossils went Marsh's great collection of fossil footprints, mainly from the Connecticut Valley and among the most extensive series in America; his invertebrate fossils, including the largest collection of nearly entire trilobites yet discovered and one of the rarest series of Silurian sponges known; his collection of recent osteology, especially rich in anthropoid apes, the gorillas being represented by no less than thirteen individuals; his archeological and ethnological specimens, mostly from Central America; and his minerals, of which the most interesting were the Nova Scotian zeolites collected before his graduation from Yale.



PROFESSOR CHARLES SCHUCHERT

PROFESSOR OF PALEONTOLOGY AND CURATOR OF THE GEOLOGICAL COLLECTIONS FROM 1904 TO 1923.

Another indefatigable collector for the museum was Professor Addison E. Verrill, long curator of zoology and still living. Of its marine fauna, he wrote in 1879:

> This collection, which is one of the largest in the Museum, is almost wholly the result of the dredging expeditions made along our coast during the last fourteen years by the curator, aided by Professor Smith and others. He made private expeditions every vacation up to 1871, when the United States Commissioner of Fish and Fisheries was organized, with Professor S. F. Baird as commissioner. Since that time the curator has had charge of the dredgings carried on in connection with the commission, and the large collections of invertebrates have been sent to him for study and distribution, with the privilege of retaining here a complete series of them.

As the present curator of zoology, Professor Wesley R. Coe, tells us, "hundreds of thousands of specimens were thus added to the museum collections, among them being hundreds of previously unknown species. These vast collections, supplemented more recently from other parts of the world, have furnished material for research by successive members of the staff in the inter-

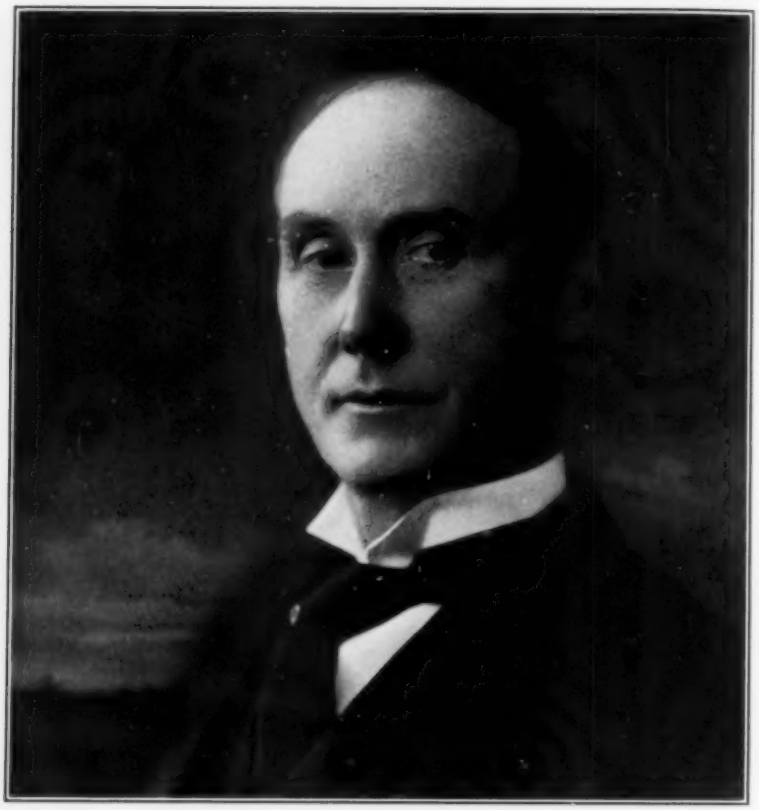
DR. CARL O. DUNBAR

ASSISTANT PROFESSOR OF HISTORICAL GEOLOGY ADD ASSISTANT CURATOR OF THE GEOLOGICAL COLLECTIONS SINCE 1920.

vening years, and even yet the work remains incomplete.''

In the nineties and during the early years of the present century the museum added enormously to its possessions. The mineralogical cabinet received the Williams collection of Chinese curios carved from jade, amethyst, rock crystal, etc., the Leonard collection and the Beadle collection, while the already extensive array of meteorites was increased by a collection of between nine hundred and a thousand stones got together by Mr. and Mrs. English after a meteoric shower in Iowa. The zoological department also prospered, adding the Hawley collection, the Eddy collection and the Perrin collection. The anthropological department added the MacCurdy collections and many others. The various Yale-Peruvian expeditions under Professor (now Senator) Hiram Bingham made still further contributions. Then, too, there were additions to the collection of vertebrate fossils, and Professor Lull explains:

> The year 1908 saw the organization of the first formal expedition in search of fossil vertebrates since before the death of Professor Marsh in 1899. This party, consisting of the writer and Hugh Gibb, for more than thirty years a thoroughly efficient and skillful pre-



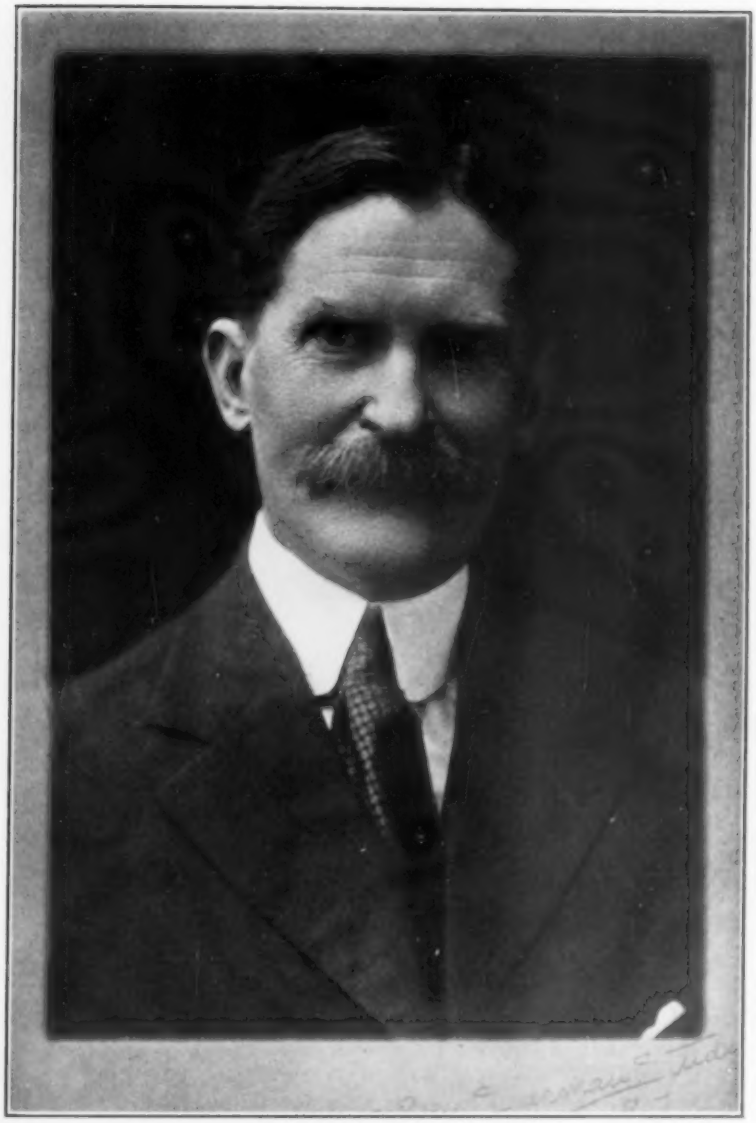
PROFESSOR GEORGE GRANT MacCURDY

RESEARCH ASSOCIATE WITH RANK OF PROFESSOR AND CURATOR OF THE ANTHROPOLOGICAL COLLECTIONS OF THE PEABODY MUSEUM SINCE 1923; DIRECTOR OF THE AMERICAN SCHOOL IN FRANCE FOR PREHISTORIC STUDIES.

parator in the Museum, joined forces with a larger party from Amherst under the leadership of Frederick B. Loomis, Professor of Comparative Anatomy in that institution. While the parties lived and traveled together, the collections were independently made. The work was done in beds of Lower Miocene age both in eastern Wyoming and along the historic Niobrara, though far to the west of the country exploited by the expedition of 1871. In spite of rich returns of camel, oreodont and other material, but few horses were secured, and those pertaining entirely to the genus *Parahippus*.

Fossil horses were then what most interested Professor Lull, and he continues:

As a direct result of the 1908 expedition, it became possible during the summer of 1912 to send a larger party to the Panhandle region of Texas with the specific aim of securing one or more complete skeletons of fossil horses for the collection. The results so far as known are the obtaining of a practically perfect skeleton of *Equus scotti*, the last survivor of the horse family in North America, and several other incomplete skeletons; a partial skeleton and many teeth and bones of a smaller, more slender *Equus*; and from the Miocene (Clarendon) beds portions of many individuals of the three-toed *Protohippus* and *Pliohippus*, and the desert *Neohipparion*. The party was also successful in securing a great deal of material other than horses. Mrs. Lull collected several specimens of *Neohipparion* and *Protohippus*.



PROFESSOR WESLEY R. COE

PROFESSOR OF BIOLOGY AND CURATOR OF ZOOLOGY SINCE 1909.

The Peabody Museum, long famous, became more and more a mecca for research specialists as its collections increased. Scientific men came from all over the world to study the exhibits, as they could find material there which could not be found elsewhere. A tremendous amount of scientific literature was based upon its collections, which in volume are second only to those of the Natural History Museum in New York and among the greatest in the world. It is impossible to pick up a single technical book along the lines of natural sci-

DIRECTOR RICHARD S. LULL

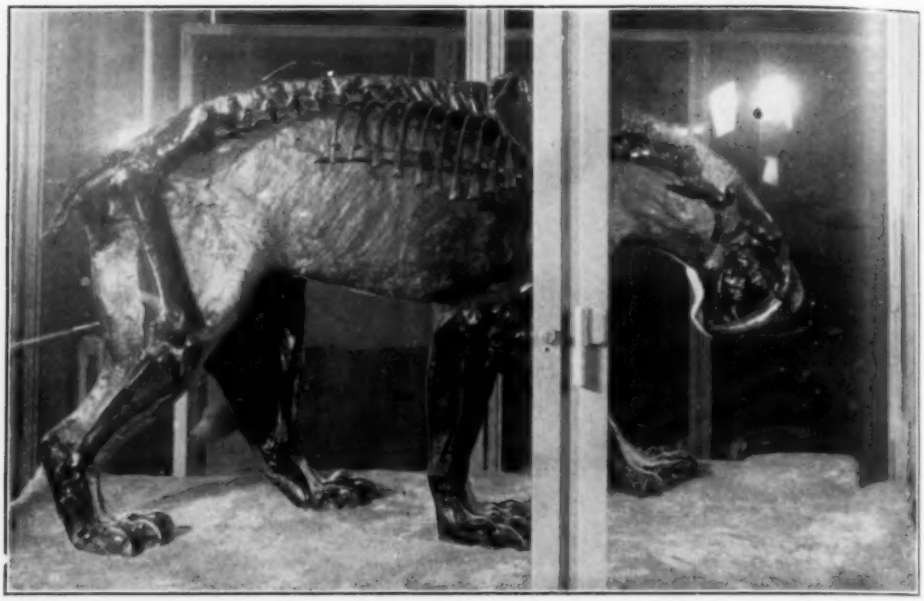
PROFESSOR OF PALEONTOLOGY SINCE 1906 AND FIRST DIRECTOR OF THE PEABODY MUSEUM.

THE PEABODY MUSEUM OF NATURAL HISTORY OF YALE UNIVERSITY
DEDICATED ON DECEMBER 29, 1925.

ence without finding some reference to the museum or to some member of its staff. Conspicuous among books written by members of the staff are Professor Schuchert's "Historical Geology," now used by two hundred colleges and universities, Professor Lull's "Organic Evolution," and Professor MacCurdy's "Human Origins."

Thirty years ago the need for expansion was felt, and the president reported that enlargement of the building "could no longer be delayed if the University and the public were to have the benefit of the unsurpassed collections which had been brought together with much labor and at great expense." Later on, the demand was repeated, becoming a chorus of demands, and chronic. The undergraduate press editorialized it. A contributor to the *Yale Alumni Weekly* versified it in the wail of a seventy-foot dinosaur crying out for room to stretch his bones. How the new building was at last promised is told in the address delivered by Professor Charles Schuchert at its dedication last December. Says Professor Schuchert:

> On the memorable Christmas Eve of 1916, the treasurer of the University came to the speaker full of the great news of the Harkness gift of a magnificent new quadrangle of buildings, and asking our help to make it possible by the removal of the Peabody Museum from its stand of over forty years at the corner of Elm and High Streets. His words are still ringing in my ears, and I hear him say, "If you can bring this about, the present Peabody Museum building fund of $250,000 will be increased to $750,000, bearing interest at the usual university rate, along with more land than the Peabody Trustees now have on the Pierson-Sage



THE GREAT SABER-TOOTHED CAT

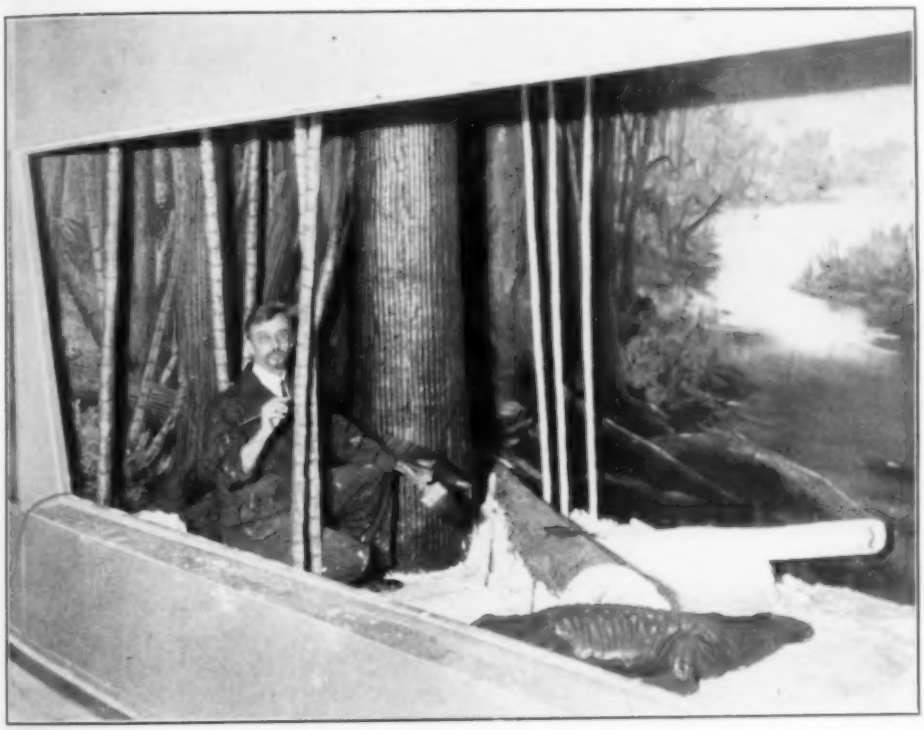
SHOWING THE METHOD USED BY PROFESSOR LULL, WHICH IS TO MOUNT A SKELETON AND THEN MODEL FLESH ON ONE SIDE OF IT, WORKING FROM THE COMPARATIVE ANATOMY OF DOMESTIC ANIMALS.

AZTEC CALENDAR STONE

ONE OF THE THREE EXTANT AND THE ONLY ONE OUTSIDE MEXICO. ON IT HUMAN SACRIFICES WERE OFFERED TWICE EACH YEAR TO THE SUN GOD.

Square.'' It was truly to be a grand Christmas present for the Museum, but, he added, ''The Museum must be erased and the property ready for the Memorial Quadrangle by July next!'' I said, ''Do you mean that we are to begin moving at once, go for two years into storage, and then move again into a new building?'' He nodded assent. I then asked him if he had not heard that ''three moves are as good as one fire.'' We laughed a ''good-night,'' but the consequence of that meeting was that the seven long years of gloom and confinement were our portion.

Moving out was a tremendous job. Provision for crating, carting and storage cost something like $23,000. Moving into the new building seven years later was a job almost as big. Over four hundred truckloads of material, largely the actual specimens, had to be hauled.



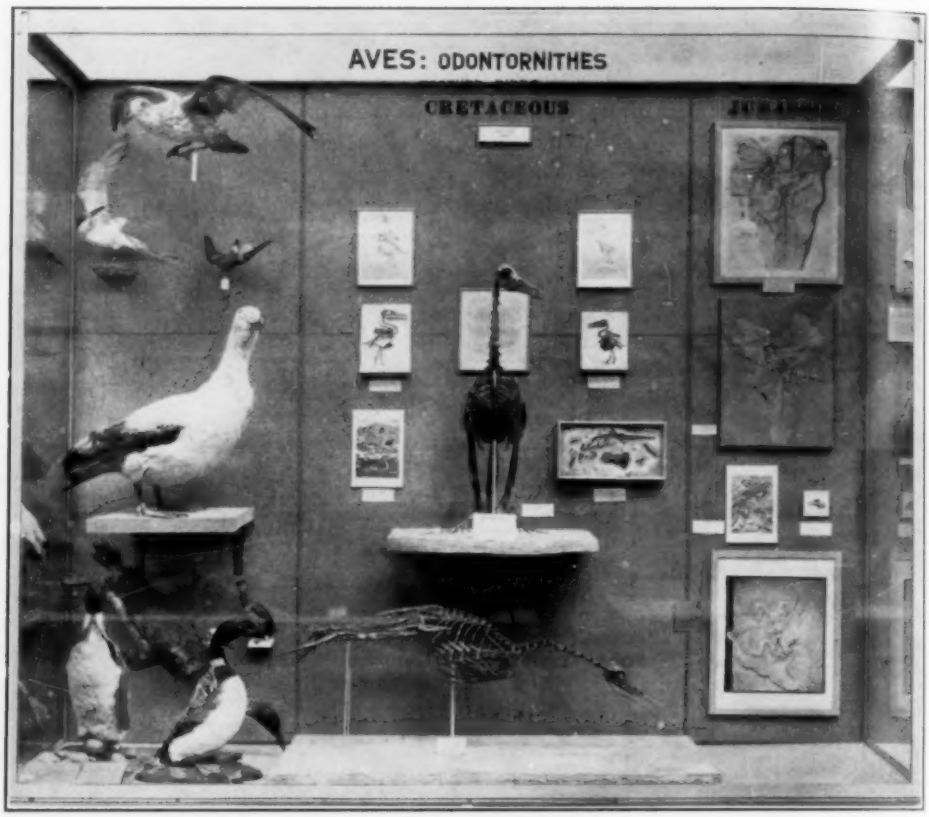
A CARBONIFEROUS LANDSCAPE

BRUCE HORSFALL, ASSISTANT EDITOR OF ''THE NATURE MAGAZINE'' AND PAINTER OF MANY HABITAT GROUPS FOR THE AMERICAN MUSEUM OF NATURAL HISTORY, IS SHOWN AT WORK UPON A REPRESENTATION OF THE PREHISTORIC COAL AGE.

seemingly impossible conditions were fulfilled, and the wreckers began the demolition of the old Peabody Museum on the date appointed.

The expectation had been that we would have to wait but two years for a new building, and our material was accordingly stored in fifteen different places. Then President Wilson put us into the Great War, and before the memorable year of 1917 was at an end, the purchasing power of our funds had decreased to fifty cents on the dollar! Instead of two years, Very little damage was done, other than that caused by deterioration during storage.

The new building, which has been described not only in the SCIENTIFIC MONTHLY, but in the *Outlook*, *Museum Work*, the *Literary Digest* and numerous other publications, is a triumph of applied foresight. Cases were designed




ODONTORNITHES FROM THE CRETACEOUS

TWO RARE SKELETONS OF TOOTHED BIRDS FIRST DISCOVERED BY MARSH.

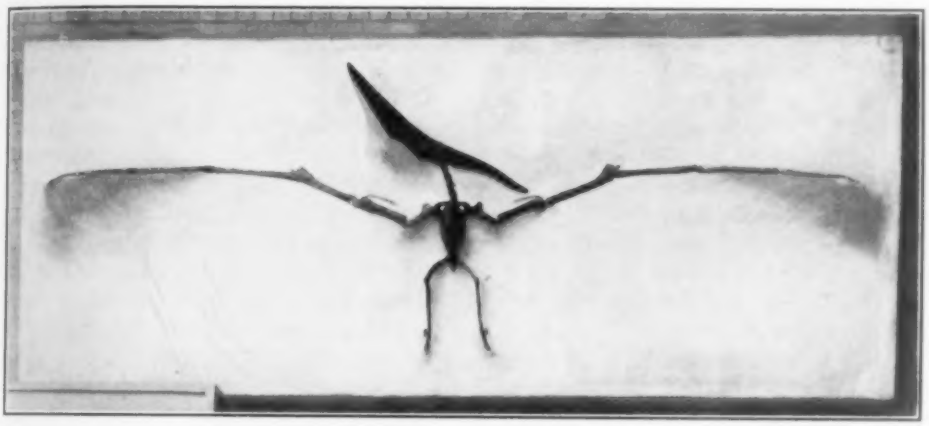
and in process of construction while the building was being erected. In October, 1924, they began to receive the specimens. By dedication day, December 29, 1925, all was ready. Costs had been so shrewdly calculated that there was a considerable sum left over from the building fund.

What, now, of the museum's future? "The museum must not stand still," says Professor Lull, "because whatever stands still goes backward. The museum could be larger; we already see that; for even the storage collections are pretty crowded, and some of that material, not yet scientifically described, has remained unopened ever since its arrival half a century ago. That is because Professor Marsh, who accumulated a vast deal of material for great monographs, seemed to believe more in immortality on earth than in immortality in another world, and died leaving only two of the great monographs completed. I have carried through a third. In course of time, more will follow, for these collections in storage are of tremendous importance. As one man has expressed it, the real scientific value of the museum lies in the basement."

Architecturally, the museum's enlargement will be a simple matter, as the Gothic permits irregularity and a new wing can be run out almost anywhere

without detriment to the design. One such addition is already planned—an auditorium. For this is primarily a teaching museum, serving the university departments.

But it is also a museum for the people of New Haven and their children. At present, it offers the children a museum within a museum. The next step will be to found a children's museum outside. Specimens are being set aside for that purpose, and intense is the interest among the children, though hardly less intense than the interest their parents have shown in the museum as now arranged. When the new building was first opened on Sunday, thirty-five hundred people came. On the third Sunday fifty-seven hundred and fifty-six came, and during the first eight weeks over forty-seven thousand.



SKELETON OF A PTERODACTYL

One of Marsh's most interesting discoveries.

# THE PROPERTIES OF STARS IN THE SOLAR NEIGHBORHOOD

By WILLEM J. LUYTEN

HARVARD COLLEGE OBSERVATORY

THE number of stars now known and the variety of their physical and astrometric properties which are open to observation are so great that we can no longer proclaim as the ultimate goal of astronomy the complete and detailed description of all the individual stars. This truly Herculean task has been considerably lightened by the application and introduction of statistical methods into the study of astronomy. And thus we put the science of statistics to its legitimate use: the combination and discussion of all observed data for the purpose of finding the general average of the universe.

As one of the principal objects of stellar statistics we may therefore consider the study of the properties of the average star in relation to the properties of the sun. It has long been known that the number of intrinsically faint stars in space is very large; accordingly it will be very difficult to obtain a representative sample of the stars in space, since these feebly luminous objects can not be detected unless they are very near us and may appear to us comparatively bright. If we limit ourselves to the immediate vicinity of the sun, we have the largest chance to find a few of these stars of low candle power.

Tabulations and discussions of the stars nearer than a given distance have been made by Hertzsprung and Eddington. With the wealth of parallaxes, as measures of stellar distances, which have come to hand during the past few years, a repetition and extension of such investigations is not without value. The writer has recently published a discussion concerning stars nearer than ten parsecs[1] and has also considered, in less detail, some properties of the stars nearer than twenty-five parsecs. Somewhat similar studies have been made by Haas and Lundmark.

The greatest difficulty immediately presents itself while compiling the material and lies in the necessity of avoiding misleading effects of selection. Unfortunately, the selection itself can not be avoided, and a great deal of time and energy has to be spent in attempts to make an adequate correction for its influence.

It does not seem necessary to describe in detail the methods employed in compilation, and it will suffice to state that, in addition to the directly measured parallaxes, statistical parallaxes obtained by a variety of methods have also been used for segregating those stars which are nearer than ten parsecs.

The list thus obtained is, in all probability, complete for stars of the same intrinsic brightness as the sun or brighter. The selection factors operative for the intrinsically fainter stars, as a result of favoritism shown by observers to stars of large angular motion (which is almost the only property through which a star can betray its proximity to us), are such as to increase disproportionately the number of stars of large linear motion across the line of

[1] A parsec is the usual sidĕral unit of distance and equal to about $3 \times 10^{13}$ kilometers.

sight. At present we have no criterion by which we can discover intrinsically faint, slow-moving stars, and our list is probably woefully incomplete for such objects.

The final list of stars within ten parsecs contains 104 entries, double and multiple stars being counted as one, and 144, if the components of such stars are counted separately. The apparent brightness, the distance and the proper motion (the angular, annual displacement in the sky) are known for all these, spectral classes have been determined for 132 stars, and radial velocities for 85 systems. For about a dozen of the double stars among them we know the elements of orbital motion.

The incompleteness of even this small sample of stars is plainly evident in the comparison of the numbers of stars nearer than five parsecs and between five and ten parsecs. The respective numbers known are twenty-seven and seventy-seven, whereas the portions of space through which these stars are scattered are in the ratio of one to seven. Hence we conclude that less than one half the expected number between five and ten parsecs are as yet on record. Making allowance for these undiscovered stars, we might state that in the solar neighborhood there occurs, on the average, at least one star in every twenty cubic parsecs of space.

Immediately passing to a statistical description of the distribution of the principal properties, we begin by considering the intrinsic luminosities. According to Kapteyn, the distribution curve of the absolute magnitudes, quantities corresponding to the logarithms of the luminosities, should be similar to a normal error curve; our data, however, show a marked departure from this symmetric form of distribution. The discrepancy is in the sense of a rapid increase toward a maximum frequency and a slow falling off afterwards. Giving due consideration to the selection inherent in the present material, this points to a significant excess of absolutely faint stars over the number predicted by Kapteyn. Additional evidence derived from the lists of faint stars with larger proper motion, published by Wolf, also indicates a decided excess of feebly luminous stars.

Kapteyn's normal error curve for the distribution of absolute magnitudes had its maximum at 7.7, corresponding to a luminosity eleven times fainter than that of the sun. For purely practical reasons, that is, for convenience in statistical description, it seems best to retain the analytical form of his curve for the present. Fitting such a curve to our data we now find the maximum frequency at absolute magnitude 9, corresponding to a luminosity forty times fainter than that of the sun.

It has long been known that a relation exists between the total luminosity of a star and its spectral class, which is a measure of the temperature, and therefore of the surface brightness. In the diagram are represented all the stars for which accurate data are available; the ordinates measure the logarithm of the intrinsic brightness and the abscissae measure the spectral class on the Harvard system, where A corresponds roughly to a temperature of 11,000 degrees centigrade, and M to 3,000 degrees centigrade. The stars represented by the three dots in the lower left corner are notable exceptions to the general rule that decrease in luminosity is connected with decrease in temperature; for the other stars, however, this rule appears to be almost in the nature of a one-to-one correspondence.

As has been mentioned before, it has been possible to derive the complete elements of orbital motion for some double stars. Using Kepler's third law of planetary motion for a comparison be-

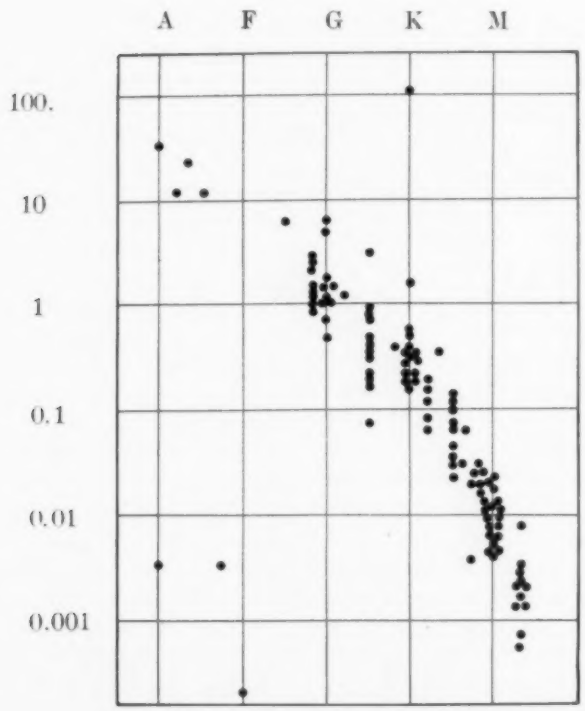



FIG. 1. THE RELATION BETWEEN SPECTRAL CLASS, AS A MEASURE OF TEMPERATURE AND INTRINSIC BRIGHTNESS, INDICATED AT THE LEFT OF THE FIGURE, IN TERMS OF THE SUN'S LUMINOSITY AS UNIT.

tween the sun-earth system and these double stars, their masses may be calculated. A provisional relation between mass and luminosity is thus established in good accordance with the results derived by other investigators. The curious fact is shown that, whereas the luminosities of the stars differ enormously, at least in the ratio of one to one billion, the differences in mass are much smaller, probably not much exceeding the range from one to one thousand.

Owing to the fact that stars with large angular velocities are more easily discovered and that more attention is paid to them by observers of stellar distances, the list used in the present investigation contains a preponderance of stars with large linear velocities and is not a true image of the condition in space. In spite of this, it may be of interest to examine the distribution of these velocities in size and direction.

The linear three-dimensional velocities have been computed from the radial velocities, the angular proper motions and the parallaxes. All motions are measured relative to the sun. It is not surprising to find, therefore, that the distribution is not isotropic, *i.e.*, not at random in all directions, and the obvious explanation of this circumstance is to attribute space motion to the sun.

The usual procedure in determining this solar motion is to assume it to be equal in size and opposite in direction to the apparent motion of the geometric center of gravity of the stars in question, obtained by assigning the same mass to all stars. Now that we are able to deduce the individual masses of the stars

by means of the statistical relation between mass and luminosity, it is possible to determine the sun's motion with reference to the real center of gravity of these stars. An additional advantage of such procedure lies in the fact that there appears to be a statistical relation between luminosity (and, therefore, mass) and linear speed, in the sense that the less luminous (and less massive) bodies have a higher speed. Accordingly, our system of giving lower weight to the less massive stars minimizes the influence of the otherwise too preponderant high-velocity stars. The computations give us for the direction and speed of the sun's motion: R. A. 278°, Dec + 36°, V = 25 km/sec.

After applying a correction for this motion of the sun to the velocities of the stars, we obtain what we may be permitted to call the absolute space motions of the stars. Since we have thereby changed our locus of observation from the sun to the center of gravity of these stars, there seems to be no reason why we should continue to measure the velocities with reference to a system of coordinates defined by the earth and the sun. The nearest approach to a natural system of coordinate axes may perhaps be found by defining it in accordance with the symmetry in the general distribution of stars in space. If we select as Z-axis the direction perpendicular to the Milky Way plane (the galactic plane), this plane itself will become the X-Y plane. We still can choose one of the axes in this plane, and we may take it parallel to the direction of most favored motion among the stars in general. Referred to this system of coordinates, we find that the Z-components normal to the galactic plane distribute themselves in a curve somewhat similar to either a first or a second Laplacean error curve. The components parallel to the galactic plane follow a distribution very closely analogous to that of a first Laplacean curve in two dimensions. The logarithms of the absolute space velocities (the speeds) are found to distribute themselves very closely in accordance with a normal error curve.

With such a small number of cases as the present it is perhaps not relevant to try to distinguish between the various hypotheses advanced to explain the pref-

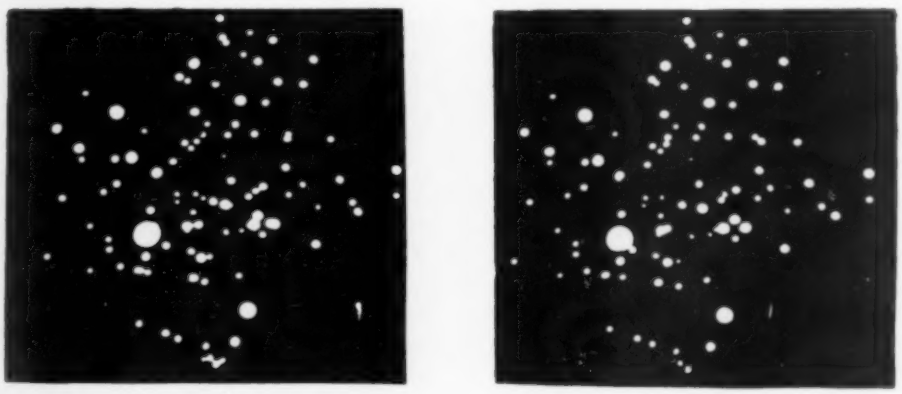


FIG. 2. STEREOSCOPIC VIEW OF A MODEL OF STARS NEARER THAN THIRTY-THREE LIGHT YEARS, AS SEEN BY AN OBSERVER SITUATED IN THE DIRECTION OF THE NORTH POLE OF THE MILKY WAY AT A DISTANCE OF APPROXIMATELY ONE HUNDRED AND FIFTY LIGHT YEARS. IN THE ORIGINAL MODEL A DISTANCE OF ONE PARSEC (3.3 L. Y.) IS REPRESENTED BY FIVE CENTIMETERS. THE DIAMETER OF THE SUN WAS TAKEN AS TWO CENTIMETERS AND THE DIAMETERS OF THE OTHER STARS ARE RELATIVELY CORRECT ON THIS SAME SCALE. TO BRING THIS RELATIVE SCALE OF STAR-DIAMETERS AND THE SCALE OF DISTANCES INTO MUTUAL AGREEMENT, ALL DISTANCES WOULD HAVE TO BE INCREASED ABOUT EIGHT MILLION TIMES.

erential directions of motion of the stars. The only significant fact worth mentioning is that the motions of these stars, rather than exhibiting an axis of preference, very clearly indicate an axis of avoidance which is perpendicular to the plane of the Milky Way.

Numerous relations of statistical importance may be derived from the material on nearby stars, especially by making use of the auxiliary quantity H, a function of the apparent magnitude m and the angular proper motion $\mu$, defined by the equation $H = m + 5 + 5 \log \mu$. There appears to exist an extremely close linear correlation between this characteristic and the logarithm of the intrinsic brightness, commonly called the absolute magnitude. Otherwise interpreted, this relation signifies a statistical increase in linear speed with decreasing luminosity.

From the total space velocities and the statistical values for the masses we are now able to derive the individual kinetic energies. Choosing the sun's mass and a velocity of one kilometer per second as units, the mean kinetic energy is found to be 2,800 (that of the sun being only 320). In C. G. S. units this corresponds to $5 \times 10^{46}$.

With the aid of the black-body radiation formula for the angular diameter of a star, and from further scanty evidence concerning the surface temperature and the specific density of the stars, we can compute the average values of various astrophysical properties of the stars in the solar vicinity, and thus roughly construct an "average" star. We recall here that we found that, on the average, one star occurs in every twenty cubic parsees, which is equivalent to $54 \times 10^{30}$ cubic kilometers. If, for an illustration, we represent this "mean free space" by a sphere of 1,000 km. radius (*i.e.*, a reduction of fifty billion to one), then the diameter of the star endowed with all average properties would be 16 mm. and the mean distance traveled by it in one year would be 3,400 mm. The average temperature (unaffected by the reduction) would be 4,000°, and its mass about four grams.

Reasoning further and treating all the stars in the galactic system, assumed to number ten billion, on the same basis, we may compare our universe with a gas under exceedingly low pressure, so low that the configuration of molecules corresponds to that of the stars in our system. In this way, we can calculate that, in the entire stellar system, a collision between any two stars would not, at an outside estimate, occur more often than once in ten trillion years.

# RELATIVITY AND ETHER DRIFT

By Professor W. F. G. SWANN

SLOANE LABORATORY, YALE UNIVERSITY

In the discussions of the status of the restricted theory of relativity brought about by Professor D. C. Miller's recent investigations, the three experiments A, B, and D, cited below, have figured prominently, and, in our comments, we may well include C, which is an experiment falling in the same category.

*A.* Professor Miller's experiment itself. This is a repetition of the famous Michelson and Morley experiment and consists in sending two beams back and forth over two equal paths at right angles to each other with the object of determining whether a possible difference of ether velocity along the two paths will show itself by causing a difference in the times taken for the two rays to complete their journeys, the test being made by seeking a movement of the interference fringes, produced between the two beams, when the apparatus is turned through a right angle.

*B.* The experiment performed recently near Chicago by Professors Michelson and Gale. In this experiment two beams of light from the same source were sent in opposite directions around a large horizontal rectangle with the object of ascertaining whether any drag on the ether, due to the earth's rotation, would show itself by causing an alteration of that displacement from their symmetrical positions which the interference fringes would otherwise suffer as a result of the earth's rotation in a stagnant ether.

*C.* An experiment made by Professor Michelson in 1897, in an endeavor to test whether a change of ether drift with altitude could be detected. This experiment was fundamentally the same as B except that the plane of the rectangle was vertical, its horizontal arms being at altitudes as different as the limitations of a building would allow.

*D.* Measurements of astronomical aberration, *i. e.*, the angles between the true and the apparent positions of stars resulting from the fact that, owing to the motion of the earth and to the finite time taken for light to travel the length of a telescope, it is necessary to point the latter a little "ahead" of the star in order to obtain the star image on the cross hairs.

Experiment A has been performed at the earth's surface and on the top of Mount Wilson (altitude 1.7 km). According to Professor Miller it indicates an ether drift relative to the earth of 10 kilometers per second in the latter case, and zero drift in the former case.

Experiment B gave the same shift of fringes as would be obtained as a result of the earth's rotation if the ether did not participate in that rotation.

Experiment C gave no difference in the times for the two light paths and has been regarded as indicating no variation of horizontal ether drift with altitude, although it does not necessarily lead to this result, provided that such variation of horizontal velocity with altitude as might exist were combined with a variation of vertical velocity over the two vertical paths sufficient to provide for irrotational motion in the sense explained below. Apart from this appeal to the properties of irrotational flow, the

sensitivity of the experiment is such that a relative ether drift of one three thousandth of that predicted by Miller could have been detected, assuming the change of velocity with altitude to be uniform up to the altitude of Mount Wilson.

### Irrotational Ether Motion and Optical Rays

The question of irrotational ether flow plays a very important part in the theory of experiments B, C and D, and it will be well to review in some detail the facts concerned with this matter.

In a homogeneous stationary medium the rays of light travel in straight lines except where they are reflected by mirrors; but even though the rays are reflected by mirrors, or travel in a non-homogeneous medium, or in a medium which is in motion, or subject to all these conditions, we know from the facts of optics that a ray which passes through two points P and Q pursues a path S between of such a kind that the time taken for the light to travel that path is less than that for it to travel any other path which joins those two points and lies immediately to one side or the other side of S. The path S is one of minimum time.[1] Now in general the path of minimum time between P and Q will be different according as the medium is stationary or is in motion. However, Sir George Stokes showed that provided the motion of medium is such that the average velocity taken around any closed path in the medium is zero, *i. e.*, provided it is of a type known as "irrotational," it will be without influence on the directions of the rays. It will influence the light velocity along them but in such a way that the alteration of time for all paths joining two points P and Q will be the same up to and including fractions of the order v/c of the whole time for the path, v being a quantity of the order of magnitude of the average velocity of the medium along the path considered and c being the velocity of light.

Now in all experiments such as A, B and C the position of an interference fringe is determined by the time differences for two rays emanating from the source and passing by different routes to the position occupied by that fringe. Since then irrotational motion of the medium will not alter this time difference to the first order of v/c, the position of the fringe will not be altered by such motion by an amount more than would be determined by quantities of smaller order. Again, irrotational motion would have no effect on astronomical aberration, since it has no effect on the directions of the rays.[2]

What, then, is the significance of irrotational motion, and why has this mo-

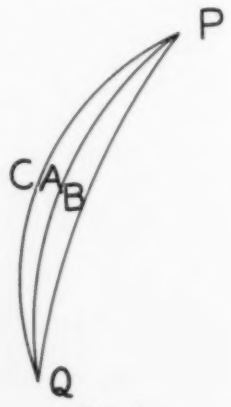



Fig. 1.

[1] In certain cases it may be one of maximum time; but in all cases it is such that a displacement of the path amounting to a quantity of the first order of small quantities in relation to its total length is accompanied by an alteration in time amounting to a quantity of only the second order in relation to the total time.

[2] There would be a very slight effect of the order $v^2/c^2$ resulting from the alteration of light velocity along the ray.

tion the remarkable property we have cited? Let us illustrate the ideas involved by considering the situation in relation to a ray PAQ, Fig. 1, passing from P to Q, there being, in the first instance, no motion of the ether. The path is one of minimum time, so that the times for any other adjacent paths such as PBQ, PCQ are greater than for PAQ.[3] Now if the medium is in motion, the velocity of light along any path at any point will be augmented (or diminished) by the component of the velocity of the medium along that path at the point. If the times for the three paths shown in the figure were increased by the same amount, the path which was one of minimum time when there was no motion of the medium would again be the path of minimum time when that motion existed. A very superficial examination of the situation shows that a whirling motion would not be the kind of motion to affect the light times equally. The sort of motion which would affect them equally would obviously be one which increased the light velocity along each path from P to Q, or diminished it along *each* path. Such a motion would be associated with a small value for the average velocity of the medium taken, in one direction, all around any path, such as PCQBP. As a matter of fact, it may be shown that a motion for which the average velocity around any path is zero is exactly the kind of motion which would alter the light times from P to Q along all paths by the same amount, and so insure that a path which was one of minimum time in the absence of the motion of the medium was also one of minimum time in the presence of that motion. A zero value for the average velocity around a closed path is the condition for what in hydrodynamics is known as irrotational motion. It is the condition for the absence of vortical motion, a motion which in its extreme form presents the features of whirlpools.

In forming conclusions as to what motion of the medium will do to a ray of light one must avoid using his intuition too freely without appeal to the principles involved in the above ideas. Thus, suppose the whole medium between the earth and a star were in motion with a constant velocity. One might be tempted to conclude that the directions of the rays would be different from what they would be if the medium were at rest. Such a conclusion would be unjustified, however, for the motion considered is irrotational in the sense that if we draw, for example, a rectangle two of whose sides are parallel to the velocity, these two sides would together contribute nothing to the average velocity of the medium taken around the rectangle while the contributions by the other two sides would each be zero.

In supposing that the motion of the

[3] For those who are interested in the more technical aspect of the matter the argument may be put as follows: If $\delta S$ is an element of the path and c the velocity of light, the time is $\Sigma \frac{\delta S}{c}$ summed along the path. If now the medium is in motion and if v is the velocity of the medium *along* the path at any point, the time for the path will be altered. Since v is small compared to c, so that quantities of the order $v^2/c^2$ may be neglected it will now be

$$\Sigma \frac{\delta S}{(c-v)} = \Sigma \frac{\delta S}{c}\left(1+\frac{v}{c}+\frac{v^2}{c^2}\right) = \Sigma \frac{\delta S}{c} + \frac{1}{c^2}\Sigma v\delta S$$

Now it is clear from the above that, if the motion of the medium is such that $\Sigma v\delta S$ is the same for any path joining P and Q, the times of all such paths will be increased by the same amount on account of the motion of the medium so that the path which gave the minimum time when the medium was everywhere stationary will also give the minimum time when it is in motion provided that the motion is of the type considered. If $\Sigma v\delta S$ is the same for all paths from P to Q, the value of this sum when taken along one path from P to Q and back along another path from Q to P will obviously be zero. In other words, the average value of v taken along the path will be zero, and, as we have stated, motion satisfying this condition is said to be irrotational.

ether, brought about by the earth's motion through it, is of an irrotational type we are confronted with a serious difficulty. The normal component of the velocity of the ether relative to the sphere has to be zero according to the ordinary ideas of fluid motion. But, with this condition assigned, it turns out that the solution for the motion of the ether everywhere else in space is completely determined. There is no latitude available to require anything else of the motion; and it turns out that the motion which the calculation reveals corresponds to a very considerable tangential velocity of the ether relative to the surface of the sphere. While this would not affect experiments B, C and D, since the whole motion is irrotational, it would affect experiment A as applied to the earth's surface; for the effect of ether motion sought in this experiment depends upon the square of the ratio of the velocity of the ether to that of light, and is not eliminated by the irrotational nature of the motion. In order to find some way out of this difficulty Planck tried to ascertain whether by making the density of the ether change with distance from the earth's surface, it would be possible to realize a condition in which there could be irrotational motion together with zero relative velocity normal to the surface, and an insignificant relative velocity tangential thereto. He found that the condition could be provided for by making the density of the ether in the vicinity of the earth about a hundred thousand times as dense as it is at a great distance, but it was necessary for him to suppose that this variation in density did not affect the velocity of light.

Thus the Stokes' irrotational ether with the Planck modification is consistent with B, C and D, and with the results of A as applied to the surface of the earth. It would also permit an ether drift relative to the earth at points above the surface, a fact demanded by experiment A as applied to the top of Mount Wilson. We shall presently discuss the question of whether it would permit a drift of the *magnitude* required by the Mount Wilson experiment. Another difficulty now arises, however, from the fact that if the earth carries the ether along with it in its orbital motion, we might suppose it also to drag it round in its rotation about its axis, and this would vitiate experiment B unless that drag were of an irrotational type, which it could not very well be, since it arises from the rotation of the earth. The way out of this difficulty was pointed out by Silberstein (*Nature*, Vol. 115, p. 798, 1925). Silberstein remarks "—our globe being almost perfectly spherical and having a purely gravitational grip on the ether does not appreciably drag it in its rotating motion —." Bold as this explanation seems, it is nevertheless consistent with, and indeed demanded by the hydrodynamical laws as applied to motion in a perfect fluid.

Discussing the effect of variation of ether drift with altitude in its relation to abberration, Eddington has remarked:[4]

> The difficulty is seen vividly if we consider the curvature of a ray of light coming to us from a star, taking account of this ether-flow. A ray which is vertical at the summit of Mt. Wilson will on reaching sea-level have an inclination of 7″. Thus observations of absolute star-position at mountain observatories and at sea-level will be discordant by amounts of this order. An error of the order 7″, variable according to the time of day, would play havoc with fundamental astronomy.

This result may be reached by combining the velocity 10 kilometers per second with the velocity of light, 300,000 kilometers, and so realizing an angle of deflection 10/300,000 radian, which

[4] *Nature*, Vol. 115, p. 870, 1925.

amounts to 7 seconds of arc. A word of warning must be given against making the conclusion appear too obvious, as one is tempted to do from the above line of reasoning. The conclusion is correct, but it seeks its strict justification only in the calculation of the displacement of the ray on the basis that the ray is the path of least time in both cases.

It is only in case there are no vertical velocities that the deflection 7″ calculated above is to be expected. As all agree, the seven seconds of arc deflection is annulled if the ether motion is irrotational. But, if the horizontal velocity is to increase from zero to 10 kilometers per second at an altitude of 1.7 km, the vertical velocities assume alarming proportions, as has been remarked by Eddington. Thus, to make the matter clear, suppose that all along the line ABC, Fig. 2, the horizontal velocity is

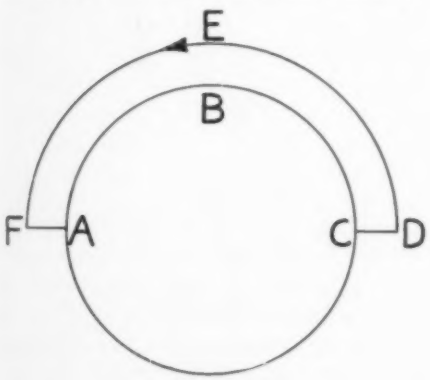



FIG. 2.

zero, and all along the line DEF at an altitude of 1.7 kilometers (the altitude of Mount Wilson) it has the value 10 kilometers per second.[5] Then, in order that the average value of the velocity along the path ABCDEF shall be zero it is necessary that the vertical velocities along AF and CD shall differ by an amount of the order U where $U \times 1.7 = 10 \times$ (semi-circumference of the earth in kilometers) so that U is about $10^5$ kilometers per second, *i. e.*, about one half of the velocity of light. As a consequence, the actual vertical velocity along one of these paths must be at least as great as this. Of course the vertical velocity difference would be less in case we should draw the two lines AF and CD nearer together. In fact the difference would amount to only 5 km/sec if they were as close as a kilometer, but the emphasis on this point by Silberstein[6] does not relieve us of the objection that there would be a vertical velocity difference of the order of one tenth the velocity of light in the case of vertical paths such as these shown in the figure. A comparatively rough repetition of the Michelson and Morley experiment with the plane of the apparatus vertical should serve to reveal these vertical velocities if they exist as Giorgi has remarked.[7]

A further difficulty concerned with the change of ether drift with altitude has been pointed out by the present writer.[8] As is well known, and as has been remarked above, when the velocity of the ether relative to and normal to the earth's surface is assigned, the problem of irrotational motion is completely determined. Further, an examination of the analysis[9] will show that, even in Planck's modification of the theory with a variable ether density, directly the ratio of the ether density at the surface of the earth to that at an infinite distance is assigned, the problem is once more uniquely determined, and with it the variation of ether drift with altitude. Moreover, it appears that there is a definite relation between the relative velocity $v_s$ at the surface and the change

[5] Of course, in practice the horizontal velocity could not be the same all along the line in question. However the figures used will serve for calculation of order of magnitude.

[6] In a letter to Science Service.

[7] *Nature*, Vol. 116, p. 132, 1925.

[8] *Nature*, Vol. 116, p. 785, 1925.

[9] H. A. Lorentz, "Theory of Electrons," pp. 314–315.

of velocity $\delta v_s$ at an altitude h, this relation being $\delta v_s/v_s = h/R$, for small values of h where R is the radius of the earth. Thus, since R = 6400 kilometers, it is obviously impossible to have for h = 1.7 kilometers a value of $\delta v_s$ corresponding to 10 kilometers per second, and at the same time a value of $v_s$ which is small compared with this, or even not large compared with it.

To sum up the situation with regard to experiments B, C and D we may therefore say that provided that one is willing to admit absence of ether drag due to the earth's rotation for the purposes of B, while ether drag due to the earth's orbital motion is admitted, and provided that we are willing to admit a light velocity independent of the density of the ether, all these experiments may be harmonized on the basis of the Stokes Planck ether theory. Moreover, A could be harmonized as regards the sensibly null effect at the earth's surface; but the theory would then contain the power to deny any appreciable relative ether drift at an altitude of 1.7 kilometers such as Miller's results require on the basis of an ether theory. Quite apart from this objection, the very existence of a change of horizontal ether drift amounting to 10 kilometers per second for a change of altitude of 1.7 kilometers would involve vertical ether velocities amounting to very appreciable fractions of the velocity of light.

### The Status of the Restricted Theory of Relativity

Of course, experiments B, C and D are consistent with the restricted theory of relativity, a theory in which an ether has no logical place and can at most occupy the position of an old pensioner who is retained out of respect for his faithful services, and because so many people know him, and for whom special provision has continuously to be made to keep him in the organization without causing trouble. Experiment A, as regards its results on the top of Mount Wilson, is, however, inconsistent with the postulates on which the restricted theory was founded. It is not without interest to inquire, however, as to how far the essentials of the theory of relativity necessitate those hypotheses. The vital thing about the restricted theory, the thing which is fundamentally operative, the thing which is of use, if it is only correct, and which is apart from all philosophical speculation as to the nature of an ether is the requirement that the laws of nature are of such a type that they are invariant under the Lorentzian transformation of coordinates.

Now let us transport ourselves in thought to the state of mind of the physics of fifty years ago, in which we suppose that there is a unique frame of reference to which the laws must be referred if they are to be true. Suppose it should so happen that the laws of electrodynamics as we have them to-day were true in that set of axes, and that the relation between that set and ours was such as the physicists of that day would have supposed on the basis of our velocity relative to that frame being about eighteen miles per second. If we in our set of axes should test the electromagnetic theory we should find it slightly in error if we could measure with infinite accuracy; but it would be necessary to measure our lengths and times to about one part in a hundred million in order to discover the errors. For we know that in terms of measures differing from ours by only this small amount, in terms of the measures given by the Lorentzian transformation in fact, these equations would be exactly right, apart, of course, from such matters as pertain to quantum theory. Thus, our measures would not be so far different from those of the Lorentzian transfor-

mation but that we should probably discover the equations of the electromagnetic theory, together with the force equation. When we had written them down on paper, some mathematician would discover that they were invariant under the Lorentzian transformation. This is a question of algebra and not of measurement. We should probably invent a restricted theory of relativity in which we supposed the Lorentzian measures to be the measures we were using. We should then form conclusions as to the variation of mass of an electron with velocity and proceed to form the Bucherer experiment. It is quite true that it is always possible to assign for the electron a velocity sufficiently nearly equal to that of light that the fact of our measures being non-Lorentzian would make as large an error as we choose to assign in our test of the formula. But we must remember that on the hypothesis that our formula was correct when measured in relation to the "fixed" frame, our measurements made in the moving frame could always be made to check the formula by altering them by quantities of the order of one part in a hundred million, so that an attempt to make measurements sufficiently near the velocity of light to show the errors in our units would cause the ordinary unavoidable errors of measurement to be of enormously greater importance than the departure of our measures from the Lorentzian measures. There is only one type of experiment which could hope to reveal to us that our measures were not Lorentzian. That is an experiment which could show up errors of the order of one part in a hundred million. Such an experiment is the Michelson and Morley experiment.

It is perhaps well to anticipate any criticism of the above remarks on the basis that in the case of motion the electromagnetic theory would itself suggest a contraction of dimensions in the electron, and indeed in matter in bulk. It is only on the rather crude electrodynamic picture of the electron moving in such a way that the total force on it is zero that the origin of the Lorentzian variation of mass with velocity seeks its explanation in a spherical electronic shell which contracts to ellipsoidal form when in motion. And as regards the Lorentzian contraction of matter in bulk, this is something which can not be predicted from electrodynamics alone without additional hypotheses, as is I believe now generally realized.

If there is a unique frame of reference to which it is necessary to refer the laws in order that they shall be exactly true in the simple form we know, then such experiments as the Michelson and Morley experiment, giving one result at the top of Mount Wilson and another at the earth's surface, must seek their explanation in a variation of the measuring system with the conditions under which the experiment is tried, and this without the necessity of any appeal to an ether theory. It is conceivable that the experiment performed in one place might give different results according as the rotation were produced in one way or another. The results would certainly be different if the rotation were produced with a sledge hammer; and there has always been an unsatisfactory element in the thought that all methods of producing the change through a right angle would converge to the same result for infinite degrees of "gentleness"; for it is not very easy to define what one means by an infinite degree of gentleness.

Nothing has been said regarding the status of the general theory in a situation of the above kind. The story in this connection is too long to enter upon here, but, in another place,[10] I have given

[10] "The Relation of the Restricted to the General Theory of Relativity, and the Significance of the Michelson-Morley Experiment." *Science*, Vol. 62, No. 1598, pp. 145–148, 1925.

arguments for supposing that the general theory can stand even if the restricted theory has to be abandoned in the sense in which it is ordinarily understood as implying the impossibility of detection of uniform motion relative to a unique frame of reference.

Finally, it may be remembered that, in the above, we have made no comment upon the validity of the experimental results of Professor Miller's work as affected by possible disturbing causes in the ordinarily understood sense. This is something on which much remains to be said. It is far too long a story to touch upon here; and, in the foregoing discussion it has not been my intention to adopt any definite attitude with regard to the matter but simply to examine the status which affairs would assume if it should turn out that the experiment in question gives a positive result when all disturbing influences (in the ordinarily understood sense of the phrase) have been removed.[11]

[11] In the April 30 issue of *Science* which has just come to my attention it appears that Professor Miller's most recent interpretation of his data is consistent with the view that there is no change in ether drift with altitude. Acceptance of this view would of course eliminate such portions of the foregoing article as are concerned with altitude variations.

# SCIENCE AND MYSTERY

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## PROLOGUE: ANTITHESIS AND PARADOX

THE subject, "Science and Mystery," suggests a prologue; yet not for those whose reading must be only running.

It is a subject that belongs properly to a time, not of ordinary, but of extraordinary transition. In time of such transition look for many pairs of important factors and interests of life, just like science and mystery, in sharp and intimate antithesis. Look, too, as disclosing the intimacy, for many startling contradictions. Look for the anomaly, not merely in politics, but in life at large, of strange bed-fellows: for radical violence, it may be, sleeping with conservativism; poverty, with riches; perhaps offensive crime with respectability; even, as in case of close conflict of any sort, death with life. Look for the disturbed and fluent conditions, for the expanding meanings, or changing values, that make such abnormal things possible.

Times of extraordinary transition are as confusing to thought as to life. Listen, and you will hear men, of possibly more insight and sudden zeal than tact or humor, proclaim of things, long supposed different, and as cordially as mutually exclusive, that each really is the other. The rich are, say what one will, so very poor. Lawlessness, truly, is become the way of real law. In transgressors behold the real reformers; in those reputed wise the quite ignorant; and, again, in such as pay no income tax at all, the really wealthy. Topsy-turvydom, then, with a vengeance! Yet, of course, in a time of transition, and it be at all critical, as just now, that is just the right name for any region, where men of insight and zeal live and, as may be their way, while giving utterance to their paradoxes and feeling the strain of the charged atmosphere and the certainty of new alignments, cry or laugh over it all.

Forbear with me, if now I remember things. In an era of extraordinary transition, 500 B. C., came that sweeping seer, Heraclitus, who could hardly open his mouth, or take up his stylus, without mingling opposites, the hearing and the deaf, the good and the bad, even the cold and the hot. Was the Greek's world changing from one of sense to one of thought? Was Greek life getting new quality? Heraclitus came into Greek history when Greece was on the verge of Thermopylae, Marathon, Salamis, Plataea, and issues of value were indeed mixed with issues of force. To nineteenth century Christendom, when was that same mixing of issues, came two men, whom I now recall Napoleon's contemporary, Hegel, whose mental pabulum, the very staff of whose mental life consisted in antithesis and paradoxical synthesis, and soon after Hegel the great naturalist, Darwin, who substituted evolution for fixity and mingled extremest organic forms, as Bryan should "make note on," even more remote from each other than man and monkey, in the organic unity of all life. True, as some may contend, those men, the subtle old Greek and the distinguished moderns, may have been only sporadic products of history; their antitheses and paradoxes, spoken or implied, may have been rather accidents of personal reflection, unconnected with contemporary conditions, than pertinent and significant reports or comments on their times; but, not to argue as to that, at least it may be said that men of such insight and startling manners would be quite timely, when

great changes are under way, and that their utterances, however abnormal and even if accidental or in origin only personal and aloofly intellectualistic, do suggest actual vision and feeling for the contemporary situations.

It is true that at such times, in fear of losing station or some so-called "faith" or even money, many may still cultivate normal living and the simple thinking of "common sense," being bent on holding intact the *status quo* and all the vested comforts and satisfactions of it and not even hearing, although having ears; but, however great their number, they can neither prevent the general sense of preparing and impending changes nor, blinding the contemporary seers to the critical antitheses, stop their utterance of the disturbing paradoxes. Such seers and prophets, I take it, may easily be of the sort that are not without honor save among their own people.

Was it, too, only accidental and "intellectual" that for each one of those three abnormal thinkers, as in one manner and another he announced his strange insights, there was no stability anywhere, no immutability? All things were in flux, moving, flowing, evolving. Extremest differences were at best only relative and were constantly disappearing, revealing likeness after all, and were, moreover, no sooner reconciled or seemingly identified than they broke out again in novel ways, with changed meanings or values, on new levels. Syntheses, in other words, or adaptations, could be no more stable than differences and conflicts, and this besides. Complicating but greatly enriching all the issues of unity and difference, of synthesis and antithesis, there were the never failing but certainly most fortunate double meanings, the repeated values on different levels, and so the mixed issues.

Double meanings may bridge the worlds of sense and thought. They may bridge old and new. Bridging of some sort would seem to be their great function. I wonder, indeed, if there could be progress at all, biologically to new life, morally to better life, or spiritually to another life, without double meanings and their bold mingling of issues of value, or kinds, with the mere issues of opposition in kind. Doubtless a difficult view for minds with the set ways of practical "common sense" and normal commensurability; and many, possibly most, may not even care to try to understand it; yet, whatever meaning it may have to quite confirmed metaphysicians and cosmologists or even to the more sympathetic moralists, sociologists and the like, we all know that sometimes, quite in defiance of practice and common sense, it counts tremendously. The physically weak, for example, even among the wholly uneducated and uncultured, may be spiritually so strong. Yes, there are times when the profoundest subtleties count a lot even in ordinary life, bringing at least poetic harmony to a divided world. Could there be any unity of human society on any other plan? It may be quite poetic; but only if there be at least two different ways, one reactionary, the other progressive, perhaps one practical, the other idealistic, of loving and honoring one's country, can we all be patriotic. Existence may not need double meanings and mingled issues and poetry; but life and its progress would be mere existence without them.

Is special illustration of all this about antithesis and synthesis, paradox, double meaning and mingled issues, now desired? What comes to my mind may puzzle quite as much as it illustrates. *Similia similibus illustrantur.* The forbearance, too, already asked must be continued a bit longer. In Luther's time of transition, when beyond question things and meanings, or values, were in flux, how very different, yet how strangely alike, were spiritual and physical, or natural, become. So alike were they that it became necessary to separate them! How different were the Church's

spiritually confident but temporarily supported theocracy and the State's physical and militaristic but at the same time spiritually sanctioned monarchy; and, again, how also alike; how, to borrow not at all impertinently from the contemporary theology, consubstantial were the divine and the human, "of one substance" with each other. Emperors and kings had actually been raised—at the time a notable advance!—to the high level of popes, being hailed as *also* in their exalted offices "by divine right." The Church, too, had turned as worldly and Machiavellian as the State and in general the real authority or support of either was quite dependent on the very different strength of the other. So different, then, yet also so alike, were the spiritual and the temporal become.

To what result? What really did happen in history, as holiness, not only in the fourth to sixth century creed, but also in the sixteenth century institutional life, proceeded alike from the spiritual and from the natural or secular, *ex patre filioque?* What did happen? Luther and Machiavelli both assisting, as if two silent partners in a single cause, each acting from his different side, spiritual and secular were separated. So the historians have commonly made record. Only, somewhat to the confusion of the record, both State and Church, institutional representatives of the two, were so changed as they were separated that their divorce was possibly merely a fiction after all. It has ever been confusing to have things refuse to stay put, while one is saying wise things about them. The separated State became constitutional and democratic, recognizing the individual; the separated Church, Protestant and more personal, humanly personal, than institutional, the institution itself becoming ever more instrumental and adaptive; and each was thus raised into a region of new meanings, under which the two, albeit historically separated, were for their own later time still quite intimately associated. In very truth, whatever may be the manner of our thinking about history, the ways of history itself have not been simple!

The thirteenth to sixteenth century saints, I venture to add, had their interested and interesting part in that history and may bring more light in kind to a puzzling illustration. They were themselves such incongruous characters, mixing old and new, reaction and progress, as they did. Veritable paradoxes they were, done in human lives and purposes, at the time of Renaissance and Reformation. In them were met such separate and different elements. Were they only too faithful and reactionary Catholics or really potential and prophetic Protestants, forerunners of what was to come? Were they, again, spiritual zealots or only sensuous realists? Institutionalized mystics, literal and submissive, or disaffected individuals, humanistic and nature-loving? Watching them, as before, while watching the contemporary institutional life, we have to see, not merely some strange mingling of extremes, but also in process a real mutation of values. In the very fire of their zeal something old was being changed to something new. If any one objects, still insisting that they were essentially orthodox and only very reactionary, the reply is quick. Both the Church itself frequently called them to account with threats and persecutions, and also, as even more significant and as suggesting the cause of the Church's anxiety, in their own tense conservatism, as with their realism of sense they literally and personally reproduced the life and suffering, sometimes even the stigmata, of Him they worshipped, they did but betray the Church and involve themselves in the very movements or forces that were then active and were bringing the historic changes. The Church had a right to fear their spiritual loyalty but personal independence. Like so many others who at other times and in other

relations of life have grown tensely and assertively conservative and reactionary, those saints found and must now and again have keenly felt themselves, and still more they were seen of men, to be adopting and sanctifying the very violence which perhaps they had set out to bring to naught. The humor, conscious or unconscious, in the lives of the saints would make an interesting study!

To desist from further attempt at illustration and, if possible, even to forget Heraclitus, Hegel, Darwin and their whole tribe, there remains for this prologue, long as it has come to be, one thing more to be said. If the signs be right, our present time is very decidedly a time of transition, of more than ordinary transition. Few, if any, will dispute this even in 1926. During the war albeit not so openly since the late national election, we have been told so quite regularly, daily or weekly or monthly, as the various bulletins, the news paragraphs, the editorials, the essays, even the books, have been issued, reporting our time to us. Some of them, it is true, have sought rather to put us asleep than to arouse us; but such bulletins—or propaganda?—have come from persons or groups not themselves quite as complacent, or necessarily as righteous, as they would have others, who have sensed change and feared it, when not seeking also to exploit its conditions for their own advantage, and so have thought wise to dwell on prosperity and urge complacency. In such cultivated satisfaction can be no real evidence against present transition. Indeed, the real evidence may be just the other way. Moreover, for some years past the telltale antithesis and its unfailing and not less talkative paradox have most certainly been bulking large, giving—I say this without wishing to take the rôle of any mere alarmist—constant and effective challenge to all the bulletins, honest or intriguing, general or specific, for the *status quo*. As to the propaganda, too, and the conservatism of it, genuine or assumed, the more assertive it be, the more it must not only induce opposition, but also, quite in the way of those reactionary saints, actually do violence to the *status quo* itself and thus, however indirectly, end by bringing aid and comfort to its enemy.

How large antithesis, paradox and the ominous confusion of them have bulked in recent life and literature might profitably be made a matter of statistical research and subsequent serious reflection. Some years ago, as I recall, for a doctor's dissertation such a study was made of Coleridge, who was much given to antithesis. The conclusion was that Coleridge had used this and used it effectively as a literary device for expanding and reinterpreting the conventional ideas of whatever he was discussing or, in other words, for reproducing, in the form and movement of his writings, the conditions of transition and transmutation in life's meanings or values. For our recent and current literature, I believe, could the statistical study be made, the figures showing antithesis and paradox, movement and transmutation, would be impressive, if not also portentous. Our life and our literature have been simply alive with those things and the ferment of them. Essential factors or conditions or attitudes have been paired against each other and strangely mingled also and over and over again, only showing the disturbance and change, we have found ourselves strangely wondering, of two things sharply opposed, if there be any real difference after all between them or which of the two really is which. Most opposite things, I say, in our own recent life and thought have been thus most intimately paired: war and peace, of course; but also government and anarchy, capitalism and sovietism, nationalism and internationalism, reaction and progress, Fundamentalism and Modernism or—as only more general—dogmatic

idealism and naturalistic realism, and I venture not to say how many more such opposites at once so opposed and yet becoming so intimate. For nearly every one of them there already presses that question: Which indeed is which? Very much as the nationalists, to take just one case, after charging their opponents with proposing only a superstate narrow and nationalistic in spirit, however imperial, then justify their own policy of national isolation by arguing that so a powerful nation from its superior position can coerce or "hold up" the others, and as, on the other side, the internationalists at the same time discover among the nationalists, when judged by their deeds and policies, official and especially "unofficial," only a myth of isolation and so no pure nationalism after all, in short as those two opponents are thus mutually and hopelessly entangled, being each one on the other's side, just so and quite at large confusion reigns to-day. Everywhere old differences are breaking down; new are taking their places; values are changing; transition is the very life of our time.

And with all the other paired opposites of the time, assertively antagonistic, yet strangely intimate and exchangeable, we have those of our title, important as the others, setting vis-à-vis our reason and our faith, our knowledge and our dogma, our natural facts and our spiritual values: Science and Mystery.

Here endeth my too long prolonged prologue.

## I

### The Mystery of Science

For many of Christendom's years science and mystery have been in open opposition, notably in the warfare of science and religion. To-day, however, the opposition is nearing, if it have not already reached, a crisis, say even the inevitable crisis. Science is itself in an atmosphere of mystery.

In a way quite his own and, while not in all respects satisfactory, still suggestive and to some point, Bernard Shaw has given an account of the present situation.

> I affirm [he writes in the preface to his "St. Joan"] that the nineteenth century and still more the twentieth, can knock the fifteenth into a cocked hat in point of susceptibility to marvels and miracles and saints and prophets and magicians and monsters and fairy-tales of all kinds. The proportion of marvel to immediately credible statement in the latest edition of the Encyclopedia Britannica is enormously greater than in the Bible. The medieval doctors of divinity who did not pretend to settle how many angels could dance on the point of a needle cut a very poor figure as far as romantic credulity is concerned beside the modern physicists who have settled to the billionth of a millimeter every movement and position in the dance of the electrons. Not for worlds would I question the precise accuracy of their calculations or the existence of the electrons (whatever they may be). The fate of Joan is a warning to me against such heresy. But why the men who believe in electrons should regard themselves as less credulous than the men who believed in angels is not apparent to me. If they refuse to believe with the Rouen assessors of 1431, that Joan was a witch, it is not because that explanation is too marvelous, but because it is not marvelous enough.

Now Shaw may strike many as rather too playful and superficial for quotation here. Surely credulity about angels is not of the same quality or purport as credulity about electrons. Granted; but also the two may not be as far apart as at first seeming to be. To every time its own wonders; and our present time of science, climax to an era inaugurated about in Joan's century, really is, as Shaw suggests, a time of wonders as no time has ever been. Our wonders may not be like those of her time; but also the context of life to-day is not the same. All things are relative. In any case, too, just here being the crisis, to which we have come and which must mark some great change in Christendom's developing romance, it is immediately in and through science, not apart from science or in opposition to science, that our day's mystery is coming to us. With all their long antagonism our science and our mystery are at last come to be most intimate, while the external mysteries that

once held our interest no longer satisfy us spiritually or even puzzle us intellectually. These objects of what we now call superstition or with less offence blind and pious faith, in sharp distinction from seeing and unfeeling science, are no longer mysterious, being given place in our attention only as they meet or fail to meet the current tests of truth or error. We simply regard them as explained or explainable. A New York divine, apparently hoping to rescue some of the old mysteries or at least to preserve the "religious" awe of them, in a recent essay, "The Vulgarization of Religion,"[1] urges a restoration of now neglected altars and bids preachers and other spiritually minded persons to abandon their scientific discourses, their "obstetrical sermons," their vulgar and secular ways, which only reason and utility can have prompted, and so save for man and man's religion the great mysteries of a cherished past. Those mysteries are so sacred! What matters their truth or error? Never so, however, may he or any other recover what has disappeared. Men may find mystery where it is, not where it was. Here doubtless is real humor, but not open to all: The one-time wonders of religion, or of faith generally, subjected even unfeelingly to rational tests! The truths of once cold science revealing a magic world, a fairyland, that challenges belief and calls Christendom out of its confining stronghold to new and profounder adventure! Science, nothing else, is become our day's wonder.

Were we really losing mystery to-day, were spiritual values quite out of date, any reference to humor would have been, to say the least, in bad taste, as well as very ill-advised, and we might well worry greatly, being left with no choice but really to abandon all the altars and let religion and all that goes with it give full place to calm reason and mere calculable utility and efficiency. Mystery, however, for life in general is to-day become greater and nearer than ever; profounder, too, and of finer, subtler quality, even as the life itself in its understanding and in its activities is profounder and subtler. If only men would seek it where it is to be found, not at some merely rebuilded altar and vain cenotaph.[2]

The rise of science has been like the coming of day. There were the dark ages. Followed the Renaissance, with mists and colors and hopes so like the dawn. Then, the clearer and ever higher rising light of knowledge and reason. Is the story too familiar to be told again? In briefest summary, a supernaturalistic theology and, for the life on earth, a theocratic and institutional absolutism gradually gave way to naturalism both in thought and in practical affairs. In the control of man's thinking natural mechanics first took the place of the theology and its mechanical but nature-aloof institution. Then Darwin's biology succeeded the seventeenth and eighteenth century mechanics, which at best had been rather formal, or even say institutional, than close and vital in its naturalism. To-day anthropology and most intimate psychology become freely and

[1] By W. J. Dawson. See *The Century*, September, 1924.

[2] Even while I have been writing, the sun's total eclipse of 1925 has come and gone. Has no wonder attended this? Wonder there has been; but it has been, not at the strangeness and the suggestion of some unnatural influence, but at the predictability. In former days mankind reacted to the strange and unnatural, to the "supernatural," in characteristic ways, with various ideas of reference and valuation. To the newer wonder, to the predictability and all that this means as to man's nature and his world, the reaction must be different, but not less real nor less adventurous. Up to the present time we have been on the whole so conscious of the passing of the wonderful and "supernatural" and the coming of the predictable that the really more intimate wonder of the new has for most part escaped us. Only now are we beginning to realize how we have been face to face with real wonder for a long time.

candidly natural sciences, have supplanted in primary interest the evolutional but on the whole still man-aloof biology.

So, with the passing centuries, has science risen over Christendom, slowly dispelling the early wonders and miracles of all sorts, bringing man, his reason and his will, into ever fuller accord with his world, registering successive steps in a progressive adaptation, become to-day in some sense even identity, of man and nature; until, what with the psychological revelations, on the one hand, and the contemporary discoveries of the physical and objectively natural sciences, on the other, announcing a new environment to us even as inwardly we have found a new self, the one time darkness seems dispelled. Specially noteworthy is the fact that with the rise of natural psychology, dramatic climax in the succession that began with theology, there has been developed a no less remarkable natural technology under which the method and manner of life have been greatly changed.

But what has been the result of science's rise and illumination? Greatly and increasingly exhilarated with the splendor of the moving day, we are now becoming dazed. Has the light possibly exposed too much? Just when we are seeing most, we find ourselves wondering anew. Just when our science is clearest and deepest, at once most intimately human and most comprehensively natural, many are making it also so realistic that it hurts. They are taking it so seriously that it loses its clearness and is no longer "scientific." Our very science is casting shadows, lengthening shadows. It is even changing to a veil or mist and, as never before, we sense colors of romance and imminent adventure. Dead but yesterday, mystery is risen again. "The evening and the morning" have been only "the first day."

The day's life, too, its conduct of life, not merely its science, is charged with mystery. Was life ever blinder, in spite of—or because of!—all the light and, as should now be said also, all the efficiency? Thanks to the illuminating and applicable science, thanks to the remarkable technology but just now alluded to, we now live so differently. Again the story is familiar, even trite and tedious; but may also be retold briefly. At the beginning of our era the environment open to organization and civilization had been so enlarged as to include no longer just one or another of the different and widely separated regions of the several ancient civilizations, but the whole region of the Mediterranean. In due course, too, ere many years had passed, northern and western Europe were added. In the earlier periods, furthermore, of the struggle with this expanded and ever-expanding environment, new and strange and disorganized, man naturally felt himself, as certainly he was, aloof and unadapted. He and nature were very far apart, as if realities of two quite separate orders, one material, natural or worldly, the other unworldly and spiritual; one in some sense without, the other within. Building his inner, spiritual order, then, as it were, out of the available material, his cherished memories, and erecting so, as was certainly both his right and his wise resort, a sublimated world, or habitat, not here, but yonder, not now but hereafter, and feeling this to be real and alive with all that had ever had positive value for him, he made it present and visible in the Christian Church at once heaven's earthly retainer and Christendom's first formal device, a sort of strategical retreat, in its struggle with that environment.

In the very aloofness of that device, I submit, in its supernaturalism which was never independent of sublimated memories, and especially in the insistent, however arbitrary and militaristic exploitation of earthly human beings and present, natural resources, there was distinct adaptive value; not clearly realized

at first, it must be said, but at least distantly sensed even at first and in the outcome, which only brought to fruition the adaptation so made possible, distinctly proved. Witness, if evidence as to either the foresight or the fruition be needed, the Western Church's sanctification of materialism and naturalism and humanism as shown in that trinitarian doctrine of consubstantiability or of the equal holiness of the Father and the Son, to which allusion was made in the prologue, and as subsequently developed, until not just the Son with the Father, as it were only in a splendid symbolism, but more generally and quite comprehensively and realistically the human and natural were equated with the spiritual. So was the splendid symbolism fulfilled. As early as the ninth century, too, appeared the secular State, also already mentioned here, which claimed and got equal authority with the Church. Historically, the Holy Empire, the divinely appointed king, the pantheism of such as Bruno, and other paradoxical syntheses of spiritual and secular, divine and natural, really had very different meanings from those now often assigned to them. They all meant progress.

With such sanctification and elevation of the natural and secular there set in a process that has brought to us our very different life of to-day, effecting even a radical change in the basic instrumentation of technique of the whole life of Christendom. The earthly state and natural science, secular authority and natural law, came into Christendom together and grew up together; and with them came also objective machinery. Primarily, with whatever vicissitudes and disturbances, the State has done more than just appropriate and use; also it has, with application of the acquired and ever increasing knowledge, directly and deliberately developed its natural resources of all sorts. Wherefore, out of the natural environment there has taken form a most efficient natural mechanism, wonderfully fabricated and wonderful in its power and virtual intelligence, a mechanism of accurate registration and quick communication; and now for his adaptations man lives not so much with benefit of the old, aloof, spiritual institution as technical medium or instrument of his activities, as with benefit of his new and very different medium. Once Christendom "belonged," body and soul, directly and intimately to the aloof and supernatural institution; but its "belonging" or real membership to-day would seem to have been transferred, in effect, if not nominally, say *de facto*, if not yet *de jure*, to the new natural mechanism, the great communal complex of adjusted and cooperating modern machines and instruments of all sorts, now with minimal human effort doing man's work and even much of his thinking for him. "Automatically efficient" some are calling this mechanical system; and also "fool-proof." In its day and its way, of course, the old institution was both automatic and fool-proof; but how much more comprehensively so is our new instrument. Direct man-power, militaristically mobilized, has simply given place to objective nature-power mechanically controlled and applied; and, on the whole, both the efficiency and the security have been increased many times. The earlier instrumentation through the institution may still survive in form or shell; also it may still be important for certain ideals and purposes that it fostered or say for the great spirit of it as something quite surpassing the letter; but life itself to-day, as to its instrumentation, is directly with benefit of the new and very different medium.[3]

[3] With benefit of the new medium, I have just repeated. The benefit may prove more profound than many will at first suspect. With the new machinery, be it not forgotten, has come new and startling exposure of human nature and the two together, the automatic efficiency of the one and the intimate illumination of the other, can not but react on morals

And, as in a former essay,[4] I have thought to show and, spite of a certain difficulty that will have to be met, would now specially emphasize, the present mechanical instrumentation of our life in reality has only grown, however gradually and through whatever dramatic eras, out of the earlier. I mean that the later has been only a development of the earlier, not coming by substitution of something quite new and unrelated, but coming by advancing realization of what was, by native expansion and generalization, by a progressive realization of the original spirit. If there be any logic, or say rather any social psychology, in the sequences of history, membership in the earlier mechanical and mediating institution, God-directed and man-powered, just because of the aloofness and the accompanying human directness, must have been training for the greater freedom of our present social life with benefit of the objective, humanly free, natural mechanism, the "Iron Man" or Giant Automaton, by which the institution has been followed.

The nature of that development has seemed to me to be well presented in a simple story from the nursery, one of my "twice-told tales." A child once suffered a bump of his head against a table and at once, poor and uncivilized fellow, hit back with his head. Later, however, getting another bump, he threw one of his blocks, instead of his head, at the offending furniture and so, as I see it, exhibited in the small what in the large has made our modern and, let me also call it, head-saving and block-using civilization. The distinct advance of the child's second method over the first is obvious. I think also that no one will deny that the latter instrumentation was, spite of its important difference, only an expression of present but unrealized elements in the earlier. Of course, not just for one individual or another, but socially, corporately, as if remembering its institutional life, Christendom has to-day adopted its block-using, vicariously instrumented civilization.

My nursery tale might be analyzed for many points of analogy; but its main point has been shown and will suffice, except that it also offers help against a difficulty to which I have alluded. Save for a certain difficulty, it was said above, our present life of machinery could be seen as the only development, not displacement, of what went before. Non-human, impersonal machinery has very largely supplanted the God-caused and God-moved as well as man-powered institution of earlier times and, just because of this, there are many who have found or will find difficulty in seeing the change as at all like real development. Is it not quite the opposite? Does it not show, as something that spoils the whole picture, a hopeless loss of personality divine or human? While I can understand the question, emphatically I think not. Did that child lose personality when he withheld his head and used the vicarious block? Truly, he grew greatly in personality. He may have lost certain physical feelings of himself and in general become less dependent on immediate and superficial evidences of self; but in both depth and reach of life, in character and power, he had advanced in a long, important stride. Taught by that child, then, I believe we may now dis-

in important measure. It is only a single illustration of this that the automobile is to-day offering a more powerful influence against drunkenness than the Church was ever able to effect. Supplemented by certain principles, biological, psychological or psychiatric, of eugenics, this influence may seem, even to the most ardent exponents of individual liberty, to give point to the recent legislation. The legislation may or may not be a bit ahead of public opinion, but in view of the benefit of which I have been speaking its justification is at least among the nearer possibilities.

[4] "The Time of Day," in THE SCIENTIFIC MONTHLY, October, November, 1924.

miss the objection or difficulty of lost personality in our modern life. The more instrumentation our life enjoys and the more objective or impersonal, as well as the more automatic, the instrumentation, the greater and profounder the personality. Moreover, as we live together, socially, corporately, with benefit of a highly efficient instrumentation, like that of to-day, our personality is real as well as rich. Personality can not be physically just a matter of bruises and inflamed swellings or mere immediate sensuous conditions or contacts of any kind; nor can it any longer be spiritually only what would be merely the negation of such physical being. In our day of automobilic machinery, say of the airplane and air-mail and the lighter-than-air radio, personality, physical or spiritual, must somehow be something else; to-day, then, not lost by any means, but "risen," more real than ever and immensely enhanced. Our Iron Man is only going forward, or "carrying on," for the medieval institution in respect to personality as well as in respect to instrumentation.

Mystery, however, not personality, was our interest. Having said that the very light of our time, the science and its most penetrating exposure at once of innermost man and of innermost nature, had actually made mystery, when it seemed quite dead, live again, our evening and our morning being only a first day, I would now add that the great change in the instrumentation of life, the nature of which, even to its consequences for the personality of every one of us, has been pointed out, really carries even more striking suggestion of mystery. Belonging as we do, each of us, to the great mechanism, primarily nature's, secondarily artificial in the Giant Automaton, possessed of remarkable speed and power and wonderfully automatic and fool-proof, we simply must feel ourselves, not merely members of the great system, but also real parties to the modern adventure of it. With our modern adventure, too, that of the forerunning institution can not be compared, although fortunately for present interest, always dependent on continuity with the past, the new is, as was indicated, but outgrowth of the old and the Church's romance can have nothing to lose; rather has it everything to gain, from life's adventure in its present vehicle.

Vehicle? Nothing else. Are we taking a journey to-day any less truly than in former time? Is our present journey taking us into a new world or a new life any less truly than the pilgrimage of the Middle Ages? And this also, at least if that difficulty was really met: Can our day's adventure be any less truly an adventure of personality, human or divine, than it was then?

Pessimists, who defy the day's charged atmosphere, for which nevertheless they must have some feeling, and persist in recognizing only routine and idle automatism, need to read history. After all, automata, political or social or economic, have been set up before, although never before so effectively or so comprehensively, and have also bred their quotas of pessimists; but, when most automatic, they have brought something new, something in the way of revelation and creation. Mechanicalism and automatism may make episodes or present special aspects of history. They never tell all the history of any time.

## II

### Adventure and Valuation

What, then, of the day's journey? To what is the present journey taking us? This question and the mystery of it, thanks to science and the application of science, now confronts us.

Many there are who would insist that inquiries, either as to whence we came or whither we are going, are no longer pertinent. Simple, commonplace and

conventional folk may still be putting them, but such folk are not supposed to count, at least not among such intellectuals as my present readers. The stork is become only a common bird. Paradise has lost its place on the map. Yet, although I am hardly of the simple and conventional and although nothing so conventional as either stork or paradise, or as anything for which either of these might stand, is now in my mind, I must confess to a feeling of sympathy with those folk.

Let it be as idle as any one is disposed to have it to question whence we came; just to avoid argument or speculation on the point, biology and evolution may be assumed to have settled so much; but, in view of our time's mystery and real adventure, there is at least pertinence in wondering, as we now move with the stars, whither we are going. This wonder, I insist, is pertinent; it is also pressing; and, at this writing, its real pertinence, its pressing timeliness, concerns me much more than any possible answer to it. I shall not even attempt to answer, being not without some caution. Nor, let me say at once, is the religious import of interest in what is to come by any means my whole concern. Before I conclude, I shall take occasion to speak of religion, since of course destiny is a problem of religion. My purpose, however, is more general. I would point out that with our present wonder about destiny, pertinent and pressing as this is, with our very science bringing mystery and adventure, we have now to put new and special emphasis, where for some time emphasis has been lacking or where interest has, to say the least, been perfunctory and conventional and in need of awakening, on the values of life in distinction from the facts, conditions or means. Mystery, romantic adventure and valuation seem to me to be quite inseparable. Let any one of them belong significantly to any time and I should have to look confidently for both of the other two. Facts call for explanation; but mystery invites valuation. Years ago I read in some book on knowledge that science, even modern science, concerned with facts and their rationalization, could be only a passing phenomenon. I understood at the time what the author meant and rather resented the probably not intended but seeming disparagement of science; but to-day I feel the meaning and know there is no disparagement. The passing may be nothing less than fruition through valuation in face of the resulting mystery.

A character or quality of the valuation should be mentioned here. Life-values, in distinction from objective facts and laws, are objects of the imagination, not of the understanding, or of the poetic and emotional mind, not of the merely knowing and reasoning mind. Valuation is most decidedly not calculation. Yet this is far from implying that it is idly or emptily visionary and sentimental. However formally beyond knowledge or reason, it has its dependence on them and its own insistent and unassailable realism. Indeed, at just such a time as our own, time of transition and confusion, of mystery and adventure, of double and incommensurable meanings, the bare facts and machinery of life have actually got too "objective" to be any longer real; they have turned too abstract and artificial to be adequate; and mankind, living reality rather than thinking or knowing it, is coming, albeit through knowledge and thought, into the experience, as real, of a super-factual world. The day's realism, then, a realism by valuation, while not formally just objective and scientific but appreciative and poetic, is so only because it would be, not abstract or artificial, but quite comprehensive and vital. For illustration of such super-factual and comprehensive realism from literature Plato's "Republic" may be mentioned; Augustine's "Civitas Dei," also; and even the possibly too romantic utopian social and

political writings of the sixteenth and seventeenth centuries. Such literature, of course, has ever been prone to abstractness in its own vision, and in any case at its time the complacent or alarmed conservatives can have little if any sympathy with it or with its "too poetic" and "quite impractical" idealism. But my contention is merely that it does make a true contribution to realism. In times of natural confusion and adventure, its poetic appreciation is profoundly opportune and may rightly claim to be realistic, not visionary. Also it must replace, as results of growth always replace, the prevalent and traditional systems of vision and value. It must be, I suggest, for its day and generation as timely as real, because enlightened, insight; as vital as genius; as powerful as the life or nature it is certain to release and mobilize. To deny realism to valuation, to allow realism only to "objective" knowledge, whether ordinary or scientific, is simply to betray real life. Not even for biology does "objective" environment exhaust reality.

Biological necessities, not to say other necessities of science and its thinking, such as anthropological necessities, have recently been much considered. The biological necessity of conflict, for example, has been a favorite topic, widely discussed pro and con, and would, I think, trouble no one if candidly associated with another biological necessity, that of growth or development. No specific type or level of conflict, low or high, can be, of itself, biologically necessary. Yet conflict may be so, if growth in the type, or level, be also recognized. Besides conflict, perhaps as incidents of it and of its growth, such things as romantic adventure, always preparing under any type or routine, and poetic, superrational valuation are also biological necessities, especially in the biology of human beings; and to these biological, or anthropological, necessities our time seems to me to be responding with special significance. We have, it is true, been in an era of prosaic scientificism and objective naturalism and through this era, except for many sporadic and inevitable outbreaks of social, moral and political radicalism, of atheism and other issues of unrest and protest and disillusion, we have been guided, our life has been motivated by traditional valuations inaugurated long ago. These have sustained our various social and religious, political and moral, economic and domestic orthodoxies and automata. But, to-day, we are come into the necessity of an active and direct revaluation. Even if we have to break with the traditional, at least with the letter of it, we must bring our world of values up to date with that of the now known facts and laws. The familiar issue of fundamentalism and modernism is only a special symptom, quite too feeble, as I sometimes think, in the candor of its modernism, of a very general condition. Our life is being challenged with many fundamentalisms.

Josiah Royce, lecturing and writing in the eighties, made much of observation, description and explanation, on the one hand, and of appreciation, or valuation, on the other. To both he assigned real and important rôles and he recognized the superrational or poetic character of the latter. Where life is, there must be both facts and values, conditions and purposes, to be reckoned with: facts, or conditions, and their rational unification in laws; values, or purposes, and their appreciative, even superrational, unification in ideals; and life itself can be real, not by either, but only as it is the meeting and functioning of them both.

Wilhelm Wundt, a contemporary of Royce, biological and psychological as well as philosophical in his interest, could admit no objective fact, or law, as found in experience, whether by the ordinary uncritical way or by science's more controlled way, that must not have, with its factual or rational character, also the

value of suggesting an ideal or norm of action. Found, something that is so and so: then, for the finder, something worth while or not so, something that may or may not be of value in the always adventurous life of action. Physically what goes up must come down! Who of us in his childhood has not shouted that out, so warning his companions to scatter, as he has tossed something into the air, and laughing quite irrationally at them as they have scattered? "Safety First!" is a familiar contemporary case of facts presented, at least by obvious implication, for their ideal or normative value. But always, be it kept in mind, the values, as assessed, are quite other than the facts and different. While the valuation, although sometimes slow in realization, must always attach most intimately to the world of facts and laws, it is nevertheless of its own kind and realm. Facts and values, again, are not commensurable. Real life, then, just by reason of the intimacy and incommensurability, has need of its poet-thinkers, not to say, too, of such as in their practical living also show those too incommensurables not really incongruous and perhaps for their rash, however romantic, "inconsistency" get roundly abused.

Since the eighties a good deal of water has flowed under the bridge. Valuation and its superrationalism—when not irrationalism—have far outrun Royce and Wundt. Various intuitionisms, the thirteen—more or less—pragmatisms, several behaviorisms, certain rather uncertain realisms or naturalisms, and other more or less destructive, more or less reforming and progressive attacks upon reason have had the effect of bringing the long increasing divorce of facts and values, of real knowledge and traditional ideals and purposes, to a crisis, by discrediting the traditional and virtually mingling valuation with knowledge, or, say, by bidding farewell to all subjectivity with one hand and, if I may quote from a certain novel, "loudly hailing" an enlivened and subjectified environment "with the other." Latterly, in other words, instead of being placed side by side with reason and science and treated as coordinate, valuation and the superrational, refusing any longer to stay outside, have entered in and taken possession. Their day, too, as I incline to believe, can be little more than just begun. As for the many reactionary movements, which might seem quite to belie what I have said, even these have been in the interests of valuation and so only testify to its rising importance. So far as reactionary, too, they simply sharpen the issue. Our values must accord with our facts! The traditional values to all intents and purposes are bankrupt; a receivership, doubtless, should have been declared long ago; but their very rush to cover is a sign and, in view of the bankruptcy, unless failure and death are to come to the life that is real and worth while, we must candidly appraise our modern knowledge and then with faith and courage launch whatever adventures in politics, economics, morality or religion may be indicated. Just this, nothing less, would seem to be the present duty, our day's biological or anthropological need; and to satisfy it all the various modernisms must boldly and strongly, not weakly, meet their respective fundamentalisms, political, economic, moral or religious, in kind; that is, not just intellectually, not by arguments as to fact or natural law, but with such values, with such quickening motives, as will actually sustain life to-day. By two things man may not live wholly and honestly to-day; mere bread and blind orthodoxy or normalness.

Finally, to speak directly and specially of religion, the pious and theistic are not likely to take too much comfort from what has now been said, although some will have caught suggestion of a possible religious revival not far off and so may hope for some justification. Yet emphatically a mere revival has not been

my meaning at all. True, in current literature there is a good deal to show that many are expecting something of the sort and so are readily responsive to any possible hint of it. Many, too, are thinking that if only, whether in the sensational way or with reserve and cultural dignity, there could be a revival, our troubles of the time would be largely settled. Progress, however, not revival, has been my meaning. Here has been no justification of any orthodox husks. In view of present conditions, in view of the now critical issue of new facts and old values, we must recognize and emphasize that any revival, which simply strengthened and made more assertive a reactionary church, could be only a sin against heaven. What right would religion have so, in time of need, to betray the life of its time? Something very like a reformation, not just a revival, is what is demanded. Only so can Christendom meet the challenge in the mystery of the time.

To those, who fear, as many doubtless will, the consequences of such a movement, it may be said that our time, as told here, certainly offers a possible case for theism. Has not the argument, almost from the beginning of this essay, been for a realism of values? Apart from other evidence or suggestion, the world of values has been found not only to be as real as the world of facts but also to be most intimate with this. What is that we call nature? What, but the real basis of the possibility of all facts and their unification in law! And what may God be? What, but the equally real basis of the possibility of all values and their unification in ideal and purpose! The facts, too, and the values, albeit incommensurable, are still, as must be said persistently, most intimate; even as intimate, if with whatever Christian spirit one may modernly as well as anciently take help from a Jew, as Benedict Spinoza found nature and God; and are also "of one substance" and equally holy.

Could theism ask more? I venture to say that it has sometimes taken much less. But is God still personal? Is man immortal? These questions were bound to come, belonging as they do to our religious traditions. Yet, I incline to leave them to the speculations of theology. Any uncertainty as regards them may be only a factor of our day's great romance. What now is personality? Or man, that we may continue to assert immortality of him? Our day's adventure, we should remember, among its other wonders is an adventure in personality.

We would do well to remember, too, that the personality of God and the immortality of man, as these have been accepted by Christendom, have been on the whole relative, or pertinent, to the instrumentation of life through what has here been called a God-caused and God-started but man-powered institution. Man has been a part of the institutional mechanism, living and moving and having his real being in the Great Cause or Mover; and personality and immortality have meant whatever they have meant in just this special context. According with this context the romantic figure among men has been the soldier, doing the will of his over-Lord and, whenever his time came, entering into his reward. But, to-day, as has been pointed out, the instrumentation of life has changed radically. It has become, relatively to the personality of the soldier, an impersonal and quite vicarious instrumentation; with the result, as may be submitted, that the real criteria of personality and so of immortality must have changed. The romantic figure to-day can not be the soldier; but, so at least it would seem, the mechanic. Should I preferably have said the engineer? Possibly; but, with apologies for the persistent militaristic metaphor, the mechanic belongs more to the rank and file. The mechanic, of course, has not yet come to his own and will still seem to most anything but romantic. The term certainly carries as yet little if any

thrill of romance, whether in life or in death. Nevertheless, the soldier of tradition is dead; long live the mechanic. And the latter, while a true person, is not such in personality as was the former.

So, not to go on with a discussion which can not fail to have interest, it must now be clear why I felt constrained to speak as I did of personality and immortality. Under the theism, for which I have claimed a possible case, even God's personality can hardly be what heretofore, to speak generally, it has been. Our day's adventure, I repeat, among its other wonders is an adventure in personality and, if theism must today, as at other times, give up certain outgrown anthropomorphic ideas, the reason can be, after all, not that theism can, or ever should avoid anthropomorphism, but that man himself is coming into a profounder understanding of himself and so theistically must value his new world accordingly.

All of which is so true, too, that it is plain enough why something in the way of a Reformation is a present need. With those who have been expecting a second reformation we must feel great sympathy. Yet what the articles or theses for it are to be, who can say? Dr. Fosdick, I recall, some months ago proposed fourteen; but I do not recall that he really indicated any such effective revaluation or reformation of Christianity as would seem to be demanded by life's new instrumentation and new romance. Good Protestants, appreciative beneficiaries of Luther's Reformation, ought not to object to another. In the sixteenth century there was distinct progress in substitution of an infallible Book for an infallible Institution and, among other results, universities and schools generally grew out of that change. Today the Book has lost its infallibility and the result, as it comes to be realized, may prove at least as progressive spiritually as that which brought the era of the Book. Always with progress there must be sacrifices. The Reformation of the sixteenth century exacted them and a new movement of the kind could hardly expect its sought progress without them in telling and in crucially testing measure.

### Epilogue

As a last word, say a very short and a very simple epilogue, with which to conclude an essay that began with a long and not very simple prologue, it ought not to be hard for a would-be serviceable Christianity once more to meet the crucial test of giving up something. So often in times of transition the lesson that is at last to be learned is just the lesson that one has been teaching or preaching all the time and Christianity's original and persistent lesson has of course been that of sacrifice.

As with so much hundred-per-centism, those who insist upon holding on to every iota, to every jot and tittle, are very likely to find that they have really and hopelessly lost Alpha and Omega.

# IN DEFENSE OF THE CAVE-MAN

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CHARLES LAMB, in the "Essays of Elia," listed several popular fallacies; a small number, indeed, of the great mass of misconceptions that are accepted as truisms by non-thinking people. A most popular and prevalent fallacy of to-day is that the cave-man was a mere human beast, a brutal mate, a cruel parent and a snarling menace to all weaker than himself. Teachers and preachers use his name to illustrate all that is low and bestial in humanity. Psychologists refer to the cave-man in us, when they discuss those primitive animal traits that have come to us as an inheritance of evolution. They would paraphrase Tennyson's lines to read:

> Move upward working out the beast
> And let the ape and *cave-man* die.

Novelists, desiring to portray a character, selfish, ruthless and brutally powerful, turn to this opprobrious term. Artists of humor sketch him as grasping the hair of his mate and in the act of striking her with a club. Hence, there has developed in the popular mind a savage *par excellence*, having no soul, no affection, no delicacy, no art, no chastity, no virtue. The cave-man dragged from his remote prehistoric past to be the scapegoat of the race has, symbolically, received the sins of all his descendants.

But now he has risen from his tomb (aided by the spades of the prehistorians) and demands justice to his memory and recognition of his virtues. He can not speak, but around him in his tomb and cave home are mute witnesses of his life and conduct.

The cave-men, in whose behalf this brief is written, lived in Europe twenty to twenty-five thousand years ago. By vocation they were hunters, by avocation artists. Physically they were superb specimens of mankind, of majestic stature, averaging nearly six feet, sinewy in limb, deep chested and with a large head well balanced on a muscular yet moderately slender neck. Their heads were long and their faces broad. From their skulls it would appear that their countenances had an Asiatic cast. Their eastern origin is further suggested by the fact that they were migrants into Europe.

Such were, in brief, the physical features of the pure Cro-Magnon race; a race, however, that in time came to have variations due to different geographic and climatic environment, and, perhaps, to racial intermixtures; for they roamed far and wide over western Europe, including the British Isles, then connected with the continent. Only in the Baltic and Scandinavian areas are no traces of them found, for this region was ice-bound during their occupancy of Europe.

It is far easier to picture them in the flesh than to follow them in their daily work and play and worship and to understand their outlook on life. Yet, with the abundant material now at hand, the task is not so difficult as it first appears. They left behind imperishable evidences of their industry and culture in the form of tools, utensils, weapons, ornaments and art. These humanly fashioned stone and bone articles have been aptly called the "fossils of the mind."

It is also possible to check these evidences of their habits of life by studying the behavior of modern primitive people living under like conditions and in a

similar stage of culture. For primitive minds often respond in a parallel manner to environmental forces.

We will never know his language, although we are positive from the shape of his mouth and chin that he was articulate and had advanced far beyond mere cries, screams and guttural sounds. As to property and government, if either existed, it was in a most simple form, since these men were hunters and never constituted a numerous population. But it seems certain that they hunted in packs and that certain caves were tribal property, or belonged to a priestly caste.

Neither can we expect to know much about their family system or methods of social control, though something may be inferred from study of modern savages. Their mythology, if they had any, must also remain a mystery. As to war, the witnesses are mute. Scanty as our field seems, much direct information is obtained as to their life and habits from the refuse of their homes, their art and their graves.

Let us enter these cave homes and examine the remnants of their life and industry that these homes have yielded to the picks and shovels of the archeologists. In some are found remains of family feasts with the charred hearth and the bones from which the meat had been eaten; in others are humanly fashioned tools, weapons and utensils, the "children of their minds;" in others are bits of carved or engraved ivory, bone and horn; some conceal, in their dark recesses, galleries of wonderful engravings and marvelous paintings in color; still others contain graves where the dead have been laid to rest with affection and with a firm belief in a future life.

Few caves produce all these documents of the cave-man's habits and occupations, but by piecing the scattered evidence together we may reconstruct a hypothetical cave home which will give us a fairly accurate view of the daily life and conduct of this long vanished race.

The first and almost universal feature of the life of the cave-man is that he lived in caverns and by the sides of rocky shelters. This habit, in his case, was due to the bleak climate which drove him to the sheltering recesses and caverns. Geologists tell us that the occupancy of Europe by the Cro-Magnon races was coincident with the approach, culmination and retreat of the ice-fields of the Fourth Glaciation.

This very fact was a spur to their social development. No longer could these hunters, who came into Europe from the mild Asian or perhaps African climate, camp where night overtook them; for the nights were becoming cold, and as generation succeeded generation the European forests and park-lands were dwindling because the moisture so essential to their growth was being locked up in the great ice sheets in the north. The winters also were becoming longer and the icy winds racing down from the frozen north were bitter and piercing.

Well might a grandfather say to his son's son that the climate was changing, and tell him stories, as they huddled together in a sheltered spot, of the days when the nights were balmy, the winds mild and the lands covered with park-lands, in whose leafy retreats the hunters found pleasant shelters for their families. Or he might tell them of the tales told him by *his* grandfather when the winters were short and mild and there was little of the white snow save in the mountains and highlands. As always with mankind: the old days were the better ones.

Little did these old men, who grumbled at the cold and change, realize that the very things they growled at would lift their race to higher levels. They did not, could not, know that adversity is nature's great whip to progress. Had not the ice-age interrupted the semi-

tropical climate that prevailed in Europe during the Third Interglacial period, it is extremely doubtful if European civilization would have risen so soon to the level of to-day. Look at the tropics! There is ease and animal luxury but little progress in all its years of human occupancy.

Stefansson has pointed out that the English Puritans migrated to the New World along two different routes. Some went to the bleak Massachusetts coast, others to the sunny, pleasant isles of the West Indies. The Massachusetts Pilgrims produced descendants that have been the intellectual and moral builders of the nation, while most of the descendants of those that went to the West Indies are now lost to view and have contributed little to progress. It has been proven time and time again that where life is easy stagnation takes place.

Let us consider the advantages that were obtained by the Cro-Magnon hunters who were compelled by a harsh and seemingly unkind climate to forsake the open and take up their abodes in caves. First and most important was the attainment of a home. This marks the beginning of ownership of real property and all that ownership implies. But the real benefit of cave life came from the establishment of the family group, that small unit which is the seed of the many-branched tree of all social systems.

To assume that no family life existed before the permanent home came into being would be a great error. For, much farther back in the history of man than our subject will take us, there are many evidences both direct and indirect that man lived in families. But it was the life in a permanent home that led the way to higher development in the social complex. The home marked a distinct advance in the division of labor between the sexes. The woman became a "stay-at-home" instead of wandering with her mate in his search for sustenance. This meant more time for domestic duties; children had better care and infant mortality decreased, thus increasing the population. More time was found for material culture and the woman learned much about cooking the game, cutting and sewing of skins and fashioning ornaments, long dear to her sex. To this leisure, and it was leisure in comparison to roaming with the hunting pack, modern society owes much.

Here we may introduce some evidence in defense of the cave-man, especially against that most prevalent charge that he was a hair-pulling, club-beating and cruel mate. It is true that the evidence will be purely circumstantial but somewhat convincing.

We must open the argument on the premises that the cave-man was a hunter, and men in the hunting stage require a very large quantity of game for their support. A large population of hunters would deplete the edible animals in a comparatively short time, and we know that Cro-Magnon man roamed over a restricted area, like France, for thousands of years.

Again, it was most difficult for these hunters, because of the primitive and feeble type of their weapons, to slaughter at will. It required much patience and hard work to bring down their quarry. We may, therefore, assume that the cave-man was a monogamist, if not by choice, by necessity, as a surplus of women would overtax his powers as a provider. Among nearly all primitive people, who live in the state of monogamy, the woman is the man's equal in the home. It is where polygamy flourishes that the woman becomes the slave and chattel of men. If then the cave-man was a monogamist, his mate, we may be sure, was dear to him, if not through ties of idealistic love, then through necessity. Without her there was no one to share the work, to do the many necessary things for which he had neither time nor inclination. He held her as his most important piece of prop-

erty, and when a man feels that way toward anything he will treat it kindly, whether it be a woman or a dog.

Another bit of evidence of her place in the home of the cave-man is that even to-day woman is the dominant sex among the primitive races that live in the remote, outlying regions of the earth. These races of "the fringe" retain to a greater extent than others the unadulterated primitive cultures that each race passed through.

With few exceptions polygamy is usually the result of wars, depleting the male population, or prosperity, through which men are enabled to buy wives, the number being limited only by the worldly goods of the purchaser. As no evidence exists that the cave-man engaged in wars or was rich in lands or herds, the testimony again points to his habit of monogamy. Hunters, especially those that live exclusively by the chase, seldom purchase wives, while those in the agricultural or pastoral state are the greatest buyers of women.

We have studiously avoided introducing any element that could be called emotional in defending the cave-man against the charge of cruelty and complete bestiality. Yet it is permissible to look at him as a human being and accord him natural kindness and even the glimmerings of conjugal love. For, if the gorilla will fight for his own and sit the night through with his back against a tree in which his mate and offspring are sleeping, we violate all the laws of evolution if we deny that sympathy and affection were totally absent from the breast of our ancestor of twenty-five thousand years ago. But, without reading pathos into the evidence, it has been shown that economic conditions and a natural balance between the sexes, with propinquity added, especially the latter, produced affection akin to love.

A mastiff dog
May love a puppy cur for no other reason
Than that the twain have been tied up together.

This same bond of unity and mutuality, which united the cave-man to his mate, extended to other members of his family and probably influenced the unity of the tribe. Stefansson says of the Eskimo, whose hunting, culture and harsh conditions of life resemble that of our European savage: "In a difficult struggle for existence under hard natural conditions they have acquired the ability to live together in peace and good will."

The advantages of the home life of the caves were many. There was introduced a greater opportunity for the leisurely development of the child. He had a longer time to profit from the accumulated wisdom of his parents and they, in turn, learned in teaching him.

If human development was purely a matter of attaining physical hardihood, the roaming life in the open with sufficient food would undoubtedly promote it best. But muscular development and physical prowess are not the whole end of man. The period of childhood should be the educative period as well as the time of play. "All work and no play makes Jack a dull boy" is as true when applied to the savage Jack as it is to the civilized Jack.

Perhaps here in the home the beauty of the human countenance was developed, for Giddings says: "A relatively long period of lactation, with inability to use food requiring strength of jaw, must have changed the facial angle and the expression of the countenance."

Without challenging or supporting this statement, it may be noted that the face of the Cro-Magnon man, with its high forehead, straight and high nose, slight protrusion of the lower jaw and well-developed chin, is much nearer that of the modern European than any other race of the Old Stone Age.

This hypothetical discussion of the home of the Cro-Magnon savage would not be complete without mention of the old folk of the family group. In the

days when the hunters had no fixed abode, the old and feeble must have been a drag on the tribe. But with the home came a refuge for the old. We know this to be so, for among the many discovered Cro-Magnon graves are those that contain the bodies of old men, buried by loving hands.

The preservation of the old meant much to the culture of the family, for here was to be found a longer experience, a reminiscence of life's lessons that added much to the stock of the family's knowledge.

Turning to the evidences of the material traits of culture that lie embedded in the débris of our assembled cave home, we find a great number of silent witnesses of the cave-man's occupations, industries, dress, utensils, weapons, tools and artistic nature.

It is at once evident that he was a hunter, as nothing has ever been discovered to indicate that he had even a rudimentary knowledge of agriculture or that he possessed any domestic animals. Toward the latter part of his occupancy of Europe he became a fisherman, whether this attainment was forced upon him through the depletion of terrestrial game or whether it was made possible through the development of the knowledge of working bone is not known.

From the bones scattered around the ancient hearths, it is estimated that over two score animals were hunted by Cro-Magnon man. Chief among these were the reindeer. These mammals occupied a similar position in the life of these ancient hunters as did the bison of the American prairies to the Indians of the plains. Obermaier says: "The flesh and suet provided them with food, the tallow with light and heat, the hide with clothing and covers, the horns and bones served various industrial purposes, and the guts and tendons were used for cord and thread." Indeed, they have well been called the men of the Reindeer Age.

Beside the reindeer, his favorite animals were the horse, bison and mammoth; the latter not only gave him food but supplied him with ivory from which he fashioned ornaments. This served also as excellent material on which to execute his remarkable ability as an engraver. His fondness for the horse is well shown at the prehistoric station of Solutre, near Macon, France. Here have been found, in an area of something over four thousand square yards, bones of over one hundred thousand individuals of a small breed of horses, and, as many of these bones are charred, it would seem that horse-steak, at least in this neighborhood, was the chef d'oeuvre of the Paleolithic cooks.

In the fashioning of utensils, implements and weapons the cave-man had progressed far beyond previous races. The growing necessities of life and the accumulation of inherited experiences had produced inventions that meant much in his mastery of nature. He was no longer the roaming hunter, the itinerant camper; he had become a householder, and that meant domestic duties which called for the invention of new utensils and implements.

One of the most interesting features of the stone industry from the standpoint of home life is that thousands of dressed flints and flint flakes have been found mingled with the hearth débris of the cavern home.

It thus becomes evident that these early homes were workshops, and we can well imagine that young and old engaged in producing the hunters' ammunition and weapons and the housewife's utensils. The latter were not as numerous as the former but much more varied than during the long human history that had gone before. Among the implements probably used by the housekeepers were stone-blades, for cutting of skin for clothing, scrapers, for dressing the hides, awls and cylindrical chisels for making eyelets, bone needles for sewing, and even buttons of bone and ivory, which were often decorated with the engravings of animals. Lamps made of

stone and resembling the stone lamps of the Eskimos have been found.

The knowledge of bone-working was a most important advance to the hunter as well as the homekeeper, for he was able to construct articles that were of assistance in using his stone and wooden weapons. One of the most conspicuous horn articles was the so-called "baton de commandement." This was made from a reindeer's horn at a point where branching occurs. At this point a hole was made. For many years its use was unknown, but it is generally accepted now that it was used to grip the shaft of an arrow in order to straighten it. These were often beautifully carved with representation of animals. Another interesting bone implement is the dart thrower, an implement used to lengthen the arm and to give greater force to the dart. These were also made from reindeer horn, though some were carved from ivory. Two, at least, have been found that have notches cut on them. It has been suggested that these grooves are tally marks and represent the number of times that the dart successfully reached its mark.

During the closing stages of the cave-man's reign, fishing seems to have largely taken the place of hunting, as there is a remarkable development in the making of harpoons. At first these were simple and crude but soon developed into an advanced type having a double row of barbs.

Such were the occupations of these ancient men. Their industries were as simple as their life was uneventful. They invented new things as necessity dictated. During the hunting season the men were on the trail, slaughtering as many animals as were needed for food during the long winter months, as well as for their skins which served as material for clothes, covers and perhaps curtains.

Although no evidence is available it seems most probable that they understood the methods of drying meat and curing it, for it formed the bulk of their food. They also must have prepared and stored the skins, for many of the animals, as the reindeer, had poor skins during certain times of the year.

The long winter cave-life permitted considerable leisure and it can well be conceived that this time did much to cement family ties and to develop the culture of the savage mind. Around the cave fire the family spent many long days, the men reciting incidents of the chase and putting into new words new ideas that had come to them. All this tended to increase the family's knowledge and each generation benefited by the experiences told around the home hearths.

The most outstanding cultural characteristic of the Cro-Magnon savage was his artistic temperament. His art is well known and reached a remarkable technique. This artistic ability was largely racial, for a vast number of objects have been found that would indicate by their very abundance that nearly every savage was somewhat of an artist.

Descriptions of the marvelous art of the cave-men will have to be omitted. It is sufficient to quote Cartailhac and Breuil, famous French archeologists, who say that the polychrome paintings of these men "place them far above the animal painters of all the civilizations of the classic East and Greece;" and Professor Osborn says: "These people were the Paleolithic Greeks; artistic observation and representation and a true sense of proportion and of beauty were instinct with them from the beginning." In the face of such evidence coming from highly educated men of the twentieth century, can we still think of the cave-man as a bestial savage with no thought save the gratification of his physical being and differing only from the brute in his upright posture?

From the standpoint of his defense we are more interested in the fact that he

was an artist of rare ability than in the enumeration and description of his art. His paintings prove close observation, keen intellect, the perfect coordination between hand and brain, a knowledge of contour and perspective, a sense of beauty and color; in short, his feeling of beauty and delicacy of expression stamps him superior to all primitive races and marks him as an equal of many civilized peoples.

A study of the evolution of this art throws much light upon the influence of home life and its hours of leisure and aids us in supporting the argument that the higher qualities of these ancient hunters were due in a large measure to the conditions produced through having a permanent habitation.

During the early centuries of the Cro-Magnon's dynasty in Europe when he was a wandering hunter his art was heavy, crude and awkward. The engravings were in absolute profile and stiff in form. The paintings were composed by merely filling in the engraved lines with a single color; there was no attempt at shading or blending the colors into tints. The few pieces of sculpture found are heavy, exaggerated figurines of the female form.

The later centuries of his occupation showed a vast improvement in the technique as well as a use of greater variety of material. He used bone and horn as well as stone and ivory. The engravings not only showed the outlines of the animals depicted, but fine lines were introduced giving contour to the forms and representing the hair of the body. In sculpturing are found models of animals in clay and high reliefs are carved on bone, horn and ivory. But the culminating glory of this ancient art is found in the polychrome paintings that adorned the walls of caves and appear as frescos on the roofs.

As long as the Cro-Magnon men lived in the open, before they betook themselves first to shelters and then to caves, they had little opportunity to develop their native artistic taste; they were on the move too much, and the bones of the slaughtered animals, which were the earliest materials on which they executed their art, were left behind as they went from place to place.

Thus, their first works were largely portable pieces or light engravings etched on the walls of shelters where they stopped temporarily. Later, the art of engraving was not only better but it was much more general, indicating more leisure time for all. Furthermore, in a permanent cave home a great deal of horn and bone would accumulate, and, during the long winters when hunting was at its ebb, the hunters utilized this waste material to fashion new implements and tools, adorning them with carvings. Here we find for the first time in human history man putting his thoughts and reminiscences in writings, for these pictures were the forerunners of script. His retrospective grew as well as his prospective. Whatever may have been the purpose of this art in the later days of the savage race, we can not doubt that in its beginning it was solely for expression of thoughts and was art for art's sake.

There is one other evidence of an advanced cultural stage in our hypothetical cave, and that is that the cave-man knew how to produce fire at will. It is true that fire was utilized by men who antedated the Cro-Magnons, but among the débris of those more ancient camps there has as yet been no evidence produced that the men of those days could build a fire when they pleased. On the other hand, in the Cro-Magnon homes are remains of their fire-building apparatus. Flint scratchers suitable for striking a fire from pyrites are of common occurrence in these times, and lumps of pyrites bearing the markings of the flint matches have been found.

We have drawn aside the skin curtains of the cave-man's home and looked

upon his family life and occupation and found, not a beast, whose only concern was food, shelter and the gratification of selfish passions, but a man who was kind to his mate, who played with his children, who shared with his neighbors the meat obtained by hunting, who took care of the old and buried his dead with affectionate care; a man who, beside being a clever artisan in stone, had a sense of the beautiful, of form, of color, and could express that sense in carvings and paintings; a man who, as he looked up at the stars shining clearly in the winter sky, wondered at their mystery and had that unutterable longing for touch with the Unknown.

Let us leave the living and turn to the dead. We have glimpsed the home, let us look into the tomb. Many burials of Cro-Magnon man have been found. He utilized caves for tombs as well as for homes. A large number of his graves have been opened, and their contents have given us not merely a knowledge of his physique but have thrown much light upon his faith and beliefs.

A description of one interment will give us a concrete example of the general method of burial.

In a cave bordering the Mediterranean, in Italy, near the French frontier, known as Barme Grande, one of the famous Grimaldi caves, a triple burial of members of the Cro-Magnon race was found. One skeleton was that of a tall man, one of a young woman and one of a young boy. All were lying in the attitude of sleep, except that the arms of the woman and boy were folded in such a way that the chin rested on the hands.

With these bodies were found ornaments and implements, indicating that the friends who laid them to rest also supplied them with adornments and weapons that they might be properly equipped for the life beyond. The ornaments surrounding the body of the man were numerous and most artistic.

On his skull were perforated deer teeth and joints of fish vertebrae, with a number of perforated shells of the genus Nassa, a whelk-like gastropod. It seems quite certain that the different materials were originally woven into a headpiece. Around his neck were the remains of a necklace composed of fourteen teeth of the red deer, perforated and engraved on their crowns, and fish vertebrae. Also there were large pendants of engraved horn. Near his left hand was a fine flint-blade nine inches in length and two inches wide.

The boy was similarly equipped for the death journey, for there are remains of a cap composed of the same materials as that of the man's, and a wonderful necklace which in its original condition was composed of a double row of fish vertebrae and a single row of Nassa shells. This triple row was interspersed at regular intervals with engraved and perforated canine teeth of the stag. There was also buried with him a flint-blade.

The woman, too, had ornaments, but not so many or as ornate as those of the men. At first this may occasion surprise, but among the less advanced savages ornamentation follows the rule of the higher animals, the male is the most highly ornamented. As if to atone for the lack of ornaments a very large blade had been buried with her.

In the trench where these three were interred was found a layer of red ocher. This same powder had been sprinkled over the bodies after they had been laid to rest. The result was that the bones were colored a pinkish red.

Let us interpret this grave in terms of human affection and faith. These very early men buried their dead. Such a rite is exclusively human, not being shared with any other animal. It implies that the body of a man is not regarded as a mere inanimate thing to be treated as the body of an animal.

Nearly every primitive race of to-day takes pains to either please or to guard against the departed spirit of man. In some cases the dead are buried with elab-

orate ceremonies and surrounded with costly grave goods. In others they are buried in such a way that their spirits can not return. This method is shown by binding the body tight with ligatures, or by burying it with the face down, or with heavy slabs lying over it. In fact, a few of the Cro-Magnon burials show these attempts at "binding the spirit."

Whatever idea animated the mind of the Cro-Magnons at different stages or in different individuals, whether the burial was to appease, to help or to control the spirit of the departed, it is very evident that they shared the almost universal belief of humanity that death does not end all. But from the general practice of laying the body in a sleeping position and adorning it with the most precious ornaments that the family could afford, and sprinkling it with the death-paint, we are justified in believing that the body was put away with grief and real affection.

> The scalping-knife beside him lay,
> With paints of gorgeous dye,
> That in the lands of souls his form
> May shine triumphantly.

Red is the color of life among a large number of savage races. Undoubtedly this conception arose from the fact that hunters learned that with the loss of blood death occurred. Hence, the logical step was to paint the body in death with the life-giving hue that the spirit might enter the realm of shadows with the symbol of life upon it. Or again its derivation may have come from the customs of hunters to paint their bodies red in imitation of the blood that they had received in killing the game, for much of the early hunting must have been at rather close quarters. This would stamp them as mighty men of valor in the chase. The first suggestion seems to be the most appropriate, as the bodies of women as well as men were so painted before burial. However, it is to be noticed that the Cro-Magnon children whose bodies have been disinterred were surrounded by offerings, but were destitute of the death paint.

This brief review of burial customs shows that the funeral rites were very simple and that affectionate care was taken to insure the welfare of the departed in the next world. This adds to the conviction that there was more affection than hatred and more love than fear among these people.

Imperfect as these evidences are of man's religious faith, we must remember that what remains of their convictions is only the material manifestation of their spiritual yearnings. As Ratzel says: "The profundity of the thought must not be measured by the imperfection of the expression."

A study of the art of the cave-man aside from its beauty, taste and realism, leads one into the belief that its later development at least had a close connection with his religious life. There can be but little doubt that his first works of art were done for the pure joy of expressing his artistic sense.

"Out of the love he bore them, scribing them clearly on bone." But later this art became involved in magic rites and religious rituals.

There are several salient features that are so common to all the later art that one can not avoid the feeling that more than art for art's sake was being expressed. Those magnificent polychrome paintings and forms moulded in clay were done in secret away from the public eye, for they are found almost exclusively in the remote and often inaccessible parts of caverns; they are usually representations of animals hunted for game or ferocious beasts; a great number show wounded animals with arrows or darts piercing them and blood flowing from the wounds; many of these animals, especially those who supplied the food, were so drawn or sculptured as to indicate the multiplication of the species; and, lastly, the works of art are representations of real life and not of mythical subjects.

The remoteness of the picture galleries from the family or tribal hearths indicates that the artists formed a special class who carried on their work in secret. The fact that there are many caves which are not decorated whose walls would have lent themselves very satisfactorily to mural pictures would point to the fact that certain caves must have been considered as temples and that those were the places where magic was consummated.

That so many of the animals depicted are shown with wounds and that others represent the multiplication of game clearly indicates that these pictures were meant as votive offerings to insure success to the hunter and to increase the fecundity of the game animals.

These men possessed little knowledge of astronomy, which figures so extensively in the pictorial art and religious rituals of many primitive races. They were exclusively hunters. Therefore, the sun was of much less importance to them than it was to the agriculturalists to whom it was the "life-giver," the quickener of harvests. We can thus account for the absence of the sun cult and the lack of a moon god, the deity of the seasons and the basis of most calendars.

The cave drawings are true to life. There has been no attempt to exaggerate nor to introduce strange and bizarre forms which is so often the case among men who have tried to express their religion through pictures. We find no evidence of combination of forms as the mermaid or the centaur, nor any conventionalized lines nor magic symbols which could be used to mystify the uninitiated. Indeed, from the location of the cavern galleries and their difficulty of access, it is very doubtful whether those outside of the artist craft ever gazed upon them.

It would seem, therefore, that the motives of the artists were sincere, that they really believed that such representations would have an effect on the hunter and his game supply, causing the hunter's aim to be sure and producing fertility in the animals which were essential to his very existence.

However strange a belief in the efficacy of pictures seems to us we can not help but feel that the realism of the art and its lack of hocus-pocus and the apparent absence of pretended incantations for the delusion of the masses, points to a real and honest endeavor to sway the unknowable for the benefit of the race. Is it assuming too much to consider this custom as a form of prayer? Certainly it is the expression of a dominant wish or desire.

> Prayer is the soul's sincere desire
> Uttered or unexpressed.

In this brief résumé of the material culture of these ancient hunters one can not escape the feeling that they were well above the average in savage mentality and that their culture, though extremely primitive and rudimentary, was characterized by a simplicity and purity that is not to be found among their modern representatives.

These later savages, although not much advanced in knowledge from their ancient prototypes, have accumulated a great mass of superstitions which have masked the original forms to such an extent that they have been almost lost. The primitive culture of to-day is so coated with the excrescences of voodooism, totemism, fetishism, taboo and witchcraft that it is badly diseased and its original purity defiled, not so much by any new element but by a cancerous growth originating from a normal culture but running wild and becoming an abnormal overgrowth. We should not read into the testimony left by ancient man the distorted development attained by modern savages.

If we think of these cave-men as men who were in the childhood of the race we can better understand them. They were crude and ignorant, they did not have behind them a mass of increasing

experiences, their growth toward civilization was extremely slow, but each laborious step carried them not only forward but upward; their life was simple and arduous; the climate, with its stinging goad, gave them little opportunity for slipping into degrading slothfulness; they had to meet and overcome the onslaughts of a pitiless nature. This constant battle with a changing and harsh climate sharpened their wits, developed their mentality by increasing their experiences. They grew and developed, while their kin, living in what seemed to be a better climate, "better" because life was more easy, have stagnated and remained stationary and, like a pool of stagnant water unstirred by any breeze, untroubled by any current, has allowed destructive life to grow from it until its surface has become covered by a decaying scum.

Social evils are not the outgrowth of primitiveness, they result from large populations. The cave-man had neither slaves nor concubines; these came with the acquisition of property. The pastoral and agricultural life produced wealth for the few and slavery or servitude for the many. Wealth and property incited envy; and war, raids and brigandage were the avocations of most tribal organizations.

No, it is not the cave-man whom we should blame for what is low and vile in the individual or society. His life was indeed a simple and primitive one, but it was as free from selfishness, greediness and all that constitutes "man's inhumanity to man" as any savage race of which we have any knowledge.

His empty hearths, on which no fire has been lighted for tens of thousands of years, speak of his domesticity, his opened tombs whisper of his affection and faith, and his art sings of his love for the beautiful and his humble and earnest attempts to conciliate the Unknown.

We find no evidences of his much bruited brutality or his lack of the higher human attributes. The cave-man was not a monster of bestiality, but a simple, kindly, happy hunter who toiled and struggled in the face of adverse nature, carrying humanity forward and living up to his best lights.

To him we owe much.

I and my brothers roam this rich To-day
Unhindered, unafraid, because thy feet,
Stone-bruised and heavy with primordial clay,
God's winepress trod to make our vintage sweet.

# BIRD LIFE ON MARGARITA ISLAND, VENEZUELA[1]

By AUSTIN H. CLARK

SMITHSONIAN INSTITUTION

LET us try to imagine ourselves to be where it is always unchanging summer all the year, off the northern coast of Venezuela, on the large island called Margarita, which lies about twenty miles directly north of Cumaná, midway between La Guayra and the island of Trinidad.

The island of Margarita gets its name from the unusual abundance of pearls yielded by the pearl oyster beds in the channel between it and the mainland. The island is about forty-two miles long, and is made up of two parts each with a high central peak, connected by a narrow neck. The eastern part is the larger and contains all the principal towns; the western is practically barren.

The island has three well-defined life zones. First, the flat and sandy coast region, which is exceedingly hot with the burning tropical sun almost directly overhead. The few plants are widely scattered post and melon cacti, with here and there dense patches of the dreaded "tuna," a kind of prickly pear with unusually long and sharp spines, and occasionally forbidding thorn trees. You can not really appreciate the "tuna" without an actual encounter with it. Its spines will go right through leather boots, and they are so brittle that the slightest contact breaks them off. All the animals of the region have spine tips in them, where the spines have gone in and broken off and the wound has then healed about the spine tip. The rabbits especially often have scores of spine tips in their flesh, but the birds have them, too, sometimes even in their eyes. You soon learn to dread the "tuna." The only attractive plant in this hot and barren region is a magnificent orchid, which is parasitic on the branches of the enormous tree cacti. This orchid bears a large pyramid of exceedingly fragrant flowers, which are at first white, but gradually turn brown. Sometimes there will be a number of them on the same tree and their fragrance is discernible for a long distance. The chief towns of the island, Asunción, Juangriego, Porlamar and Pampatar, are situated in this hot coastal strip.

Beyond the flat coast country there is an intermediate region of rough hilly country with a large amount of scrubby growth and many varieties of cacti.

The interior of the eastern part of the island is a heavily wooded mountain more than three thousand feet in height with its summit always hidden by clouds.

Several streams flow down the mountain and one, the most important, attains a considerable size in the rainy reason, flowing from high up on the mountain to the sea, which it enters a little east of Porlamar. In the valley of this stream at the base of the mountain is situated the little town of El Valle, in a large grove of cocoanut palms. It was in El Valle that I lived during most of my stay on Margarita.

I have never seen the booby gannets so abundant as they were in the channel between Margarita Island and the main-

[1] One of the series of Radio Nature Talks from the National Zoological Park, Smithsonian Institution; given January 30, 1926, from Station WRC.

land, and at certain times about Carúpano. They seemed to approach the land solely for the purpose of feeding, after which they withdrew to open water. Just off Carúpano there was a certain spot to which every day there came hundreds of sea birds of many kinds to fish. Over half of this congregation were common brown pelicans, and most of the rest were booby gannets. Overhead soared a score or more frigate birds, while various gulls and terns composed the remainder. All the larger members of this vast flock acted in perfect unison, wheeling about until a sufficient altitude was obtained, all diving with a great splash, then all slowly rising to repeat the performance. Every now and then a frigate bird would come swooping down upon some hapless gull. I was much puzzled at first to find a plausible explanation of the fact that day after day the birds collected in practically the same spot to feed. The water there was fully as deep as in the surrounding parts, and from the land no difference whatever was discernible. I thought I had found a possible clue to the mystery one day while I was watching some boys fishing off the end of the wharf. Every few minutes some fish or other, most often a sea catfish, would rise to the surface feebly struggling, to be almost instantly gobbled up by some watchful gull or frigate bird. I obtained a couple of these fish, but could find no marks whatever on them. The inhabitants told me that at certain times fish run ashore here by the cartload and say that it is due to large fish driving them in. It is noticeable, however, that when the fish run ashore in numbers there is always a smell of sulphur coming from the sea. This has given rise to the idea that sulphurous fumes coming up through the sea bottom poison the water. As this region is very rich in sulphur this seems a likely explanation. But it is not correct. What really happens is that when conditions are just right certain small plants in the sea, invisible to the naked eye, increase enormously in numbers. When conditions change these little plants die by the hundred millions and the sulphur in their decomposing bodies suffocates the fishes and taints the air above the sea.

Perhaps the most characteristic bird of the hot coast region of Margarita, certainly the one which most surely claims the attention of the traveler unused to the American tropics, is the buff-breasted parrakeet. One is never out of hearing of their incessant noise while near the coast, and little flocks of a dozen to twenty are continually passing and repassing. Although so very noisy on the wing, they become instantly quiet and motionless on alighting and are therefore very difficult to locate even in a leafless tree. They also show very great solicitude for a companion in distress.

Another interesting bird of the hot coastal region is the little burrowing owl. These owls are fairly common wherever the vegetation is scantier than usual. Near a large shallow lagoon where there is practically no plant life there is a colony of them. They are unsuspicious birds, and may be approached very closely before taking wing. They fly but a short distance, alighting with a series of bounds as if their legs were supplied with springs.

In this same region where the weird cacti and the parrakeets are the most conspicuous features, you hear from time to time a most familiar homelike sound which seems singularly out of place, the loud clear whistle of the bob-white or quail. In its habits as well as in its call this quail is very much like ours, and it looks much like ours, too, though it is provided with a conspicuous crest.

Other birds of this hot coastal region are the troupial, a large and beautiful oriole with a loud clear voice which it is very fond of using, the little scaled dove which when startled jumps up with a

curious sharp rattling of its wings, and a large hawk. Black vultures are common also, especially along the beaches.

In the rough and hilly scrubby country one of the most interesting birds is the buff-breasted hummingbird. In spite of its small size this is a very noisy bird, and in the early morning and again at dusk you hear its loud metallic song coming from all directions.

We have no bird which for pure stupidity and general lack of spirit can be compared with the two-banded puff-bird. With its large beak and its dark breast bands it suggests a clumsy kingfisher. It can be approached very closely before it takes alarm, and when it does fly it merely goes to the nearest available tree or bush and awaits the second approach of the intruder. Even when shot at it flies only a few yards and then alights as if inviting its pursuer to try again. Sometimes it does not fly at all, but remains stupidly staring at the cause of the disturbance. I have seen one shot without its mate, seated close to it, showing the slightest concern. The native boys sometimes kill them with stones.

In this region, as well as about the cacti near the coast, you often hear a cry much like that of the belted kingfisher, but harsher and more grating. This is the cry of the woodhewer, a brown bird with much the habits of our nuthatches, but much larger. Together with the woodhewers you find the handsome Bonaparte's woodpecker, which also has a harsh and rattling cry. The cry of these woodpeckers is so disagreeable as soon to become annoying. You can not escape them, as they are especially fond of building their nests high up in the cocoanut palms near houses. The woodhewer is more considerate, as it nests mostly in the cactus trees.

Here in the scrub you find the spine-tails, small birds with habits like ground sparrows, and the tawny cuckoo, the only American cuckoo known regularly to lay its eggs in the nests of other birds, generally victimizing spine-tails. Here also are the beautiful honey creepers, the brilliant cardinals, much the same as ours in color and in habits, the ground doves, the pygmy owls, queer little miniatures of owls, various kinds of exquisite hummingbirds, and flycatchers, gnat-catchers, mockingbirds, and some birds of other types, like martins, nighthawks and goatsuckers.

In the deep forests on the mountain slopes above El Valle the yellow-headed parrots are the most conspicuous birds. But they are only conspicuous when on the wing. In the trees they are very difficult to see owing to their green color and their adroitness at concealing themselves. You sometimes come upon a tree with a flock of parrots in it. You do not suspect their presence until suddenly they go screeching off over the tree tops. They are powerful fliers, and you often see them high in air. When flying they seem to lack both head and tail and to consist merely of two moving wings. The natives call them "loro" from their cry. There is another kind of parrot, the so-called Amazon, in these forests also.

In the still mountain woods you sometimes hear a distant cawing, and you at once suspect a crow. But the distant cawing really comes from near at hand and is the cry of the barred ant-shrike, a small black and white bird which sits up very straight and in this, as well as in its long crest, resembles our cedar waxwing.

Of all the feathered tribe on Margarita the lance-tailed manikin seemed to me to be the most pleasing and generally attractive. This little bird is dark brown, with a large patch of light blue on the back and a bright red topknot. Its clear whistle is a distinctive feature of the mountain forests. The natives call it "tintoro" from its cry.

Living only in the forest are a number of other birds, like the yellow-billed thrush, the black and white tanager, a

vireo, the mountain dove and the curious guan.

There are in all about eighty different kinds of birds known from Margarita Island, and undoubtedly many more remain to be discovered.

One day when I was on the sandy plain near the coast my attention was attracted by a flock of about twenty very large birds flying in the form of a wedge in the direction of the lagoon which separates the two parts of the island. Their size and actions suggested geese, and it occurred to me that perhaps they were flamingos.

There was one great mystery connected with the birds of Margarita which I could not solve. Near the top of a high spur of the central mountain just south of El Valle there was a large cave consisting of a spacious chamber with an entrance about ten feet in diameter and two shafts, one leading directly up through the roof, and the other slanting upward. The whole floor of this cave was covered with the whitened skeletons of small birds and mammals, the larger part being those of the small doves. I recognized a skeleton of Bonaparte's woodpecker among them, and also the remains of a mouse opossum and of a small rodent. These skeletons must have been accumulating for very many years, as in some places they were an inch deep and the ground in front of the cave was strewn with them.

The question is, What could have brought them there? The cave was high above any place where these forms could be found commonly, if at all, and no birds but vultures were seen in the vicinity. There was no evidence that any owls had ever lived inside the cave. Numbers of small bats were the only living creatures there. These were of several different kinds, but none of these kinds has ever been known to carry warm-blooded creatures. When they attack them they merely bite a hole in them and suck the blood; but most of the bats were insect eaters.

So far no one has been able to explain this mystery.

# SCIENCE AND GOOD WILL IN THE PACIFIC

By Professor T. D. A. COCKERELL
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WHILE Europe wrangles and America hesitates, the Pacific, as befits its name, stages a living drama of peace. When first invited to attend the Pan-Pacific Food Conservation Conference at Honolulu, I hesitated, not being aware that every one does what Mr. Alexander Hume Ford asks him to do. It involved a long and expensive trip, and I was not at all sure that when I got there I should not find a conference resembling many which have been held elsewhere. It would, no doubt, be amicable on the surface, and the entertainment afforded would certainly be lavish. But should we not see a number of national groups or cliques pulling against each other, seeking advantages and doing as little as possible for the common good? Even my good friend, Dr. L. O. Howard, the U. S. entomologist, who presided, confessed to me that he was not without certain misgivings. But in his mind, as I think in the minds of all present, doubts were dissipated, and we realized with enthusiasm that genuine international cooperation had been achieved. This does not mean that there were no differences of opinion, nor that controversial subjects were avoided. So far as possible, within the scope of the purposes of the meeting, every pertinent matter was freely and openly discussed, and there was no disposition to minimize the difficulties inherent in dealing with the food supply of the peoples of the Pacific area. It is probably no exaggeration to say that the feeling among the delegates was, at the close of the meetings, that a way had been found to mobilize the forces of science and good will in such a manner as to justify, in a troubled world, reasonable hope of permanent peace and prosperity.

When we ask how this was accomplished, certain facts stand out in bold relief. The first of these is Mr. A. H. Ford. When he came to Honolulu he was concerned in organizing the Outrigger Club and the Trail and Mountain Club, two of the most useful and vigorous local organizations. But having larger visions, and perceiving that Honolulu was at the cross-roads of the Pacific, he developed the Pan-Pacific Union, a sort of unofficial League of Nations for the Pacific area. The idea readily took root in the cosmopolitan and progressive atmosphere of the Hawaiian Islands, and secured the support of prominent persons in numerous countries. Every week the available members assembled at luncheon in the Young Hotel, and interesting people visiting the islands were always invited and brought in touch with the movement. It was a matter of fundamental importance, decided at the beginning, that the Union should be wholly "unofficial" and "non-political." It combined the spirit of science with that of religion, if we mean by these terms the search for wisdom and the service of mankind. Superficial people argue that such a body has no real power, neither laws nor armed forces to support its decisions. But laws and armed forces do not of themselves carry conviction or promote friendship. The way to get international cooperation is to cooperate, and this is only possible in a spirit of amity. Furthermore, all solutions for our problems depend on wisdom, which is the product of organized knowledge. Such wisdom may come

from any quarter, and science cares nothing for official sanctions. In the spirit of science, discussion is free, and each man desires to impart what he knows instead of concealing it from motives of "policy."

Thus organized, the Pan-Pacific Union became sponsor for great international gatherings. Mr. Ford insists that the Union does not hold these meetings, it merely calls them together and then they hold themselves. If the distinction seems too subtle, it is at least part of the plan to permit perfect freedom, and avoid in every respect even the appearance of undue domination. Professor Wm. E. Ritter[1] has given an excellent account of the Australian meeting, showing how seriously it was taken in Australia, and what great efforts were made for its success. Each conference is able to profit by the experience of previous ones, and has at its service the good will these have created. Thus year by year we may expect greater success and more beneficial consequences.

In spite of Mr. Ford's desire to avoid domination, he has felt obliged to make one condition which is absolutely fundamental. The various governments and institutions are invited to send delegates or representatives, but these are to be of a certain type. They must be scientific experts, or those who may be trusted to act in a scientific spirit.[2] The professional politician, who regards politics as a game for advantage or supremacy, is not wanted; neither is it desired to see "worthy" persons needing a holiday at the public expense. We should all, so far as possible, cooperate in the effort to keep out these undesirables, who would, if present in force, defeat the purposes of the gatherings. On the other hand, men of the right type, if active in political life, are the more welcome. Sir Joseph Carruthers, former Premier of New South Wales, and the Hon. G. M. Thomson, member of the Legislative Council of New Zealand, were among the most serviceable members of the convention. The latter is, indeed, also well known as a zoologist.[3] Perhaps we may say that one of the major services of these meetings is to recognize and encourage the scientific spirit in public affairs, supporting those politicians who represent it and bringing the idea to the notice of those who do not. The problems dealt with by the Food Conservation Conference were very extensive. It might create surprise that Dr. L. O. Howard, an entomologist, should be chosen as the presiding officer. To those who know him this choice is natural enough on account of his personal qualities, which make him an ideal chairman. But actually the entomology had a good deal to do with it. In the Pacific region there is hardly any subject of greater practical importance. As we listened to the discussions by representatives of the sugar-cane industry, gathered together from Cuba, Queensland, Fiji, Java, Formosa and elsewhere, it was perfectly evident that pests affecting cane in different regions, if brought to-

[1] *Science*, March 28, 1924.

[2] Those present at Honolulu (1924) included E. W. Allen, C. L. Alsberg, E. W. Brandes, Mario Calvino (Cuba), F. D. Fromme, J. Arthur Harris, W. B. Herms, W. E. Hoffman, D. S. Jordan, Kamakishi Kishinouye, Armand Krempf, S. F. Light, Sun Lin (China), C. L. Marlatt, Rokuichiro Matsujima, E. D. Merrill, E. Mitsui (Korea), H. L. Montalban, Herbert Osborn, Kintaro Oshima (Formosa), R. L. Pendleton, W. T. Pope, R. J. Rodrigues (Macao), H. N. Savage, Josephine E. Tilden, Lien-Teh Wu (Peking), V. R. H. Zwaluwenburg (Mexico), in addition to those mentioned in the body of the article, and many others, including of course the group of well-known scientific men resident in Honolulu. A very valuable member was Dr. Koliang Yih, Chinese Consul General at San Francisco.

[3] I had long known the name of Thomson in connection with the discovery and description of the extraordinary archaic crustacean *Anaspides*, and it was a great pleasure to hear from him the details of its occurrence in the mountains of Tasmania. Since returning I have received from Mr. Thomson a lengthy memorandum on the conference, reporting resolutions, etc., submitted by him to the New Zealand Parliament, and printed by order.

gether, would make the production of cane impossible. The Hawaiian Islands had already had some very severe and costly lessons in sugar-cane entomology, and relief had been found through the introduction of natural enemies from remote regions whence the pests originally come or where their close relatives were native. The Hawaiian Sugar Planters Association maintains a research laboratory, which has produced much valuable scientific work, and the government has at the wharf a Plant Quarantine Station, which has experts and appliances to prevent, so far as humanly possible, the landing of additional pests. So far as they go, these arrangements are all to the good, and it is certainly due to them that sugar cane is to-day a flourishing and profitable crop in the islands. Yet much more is necessary before we can be reasonably safe. On the side of quarantine, we want approximately uniform regulations in all countries we have to deal with, and especially adequate control of exports. It is almost incredible, to those who are not familiar with the details, how many dangerous pests, especially scale-insects, arrive at American ports every month. With all the vigilance possible it is hard to prevent the spread of pests which are continually and carelessly sent abroad. International cooperation is necessary if we are to be saved from calamity. In spite of all we were able to do, several first class pests, such as the camphor scale and the so-called Japanese beetle, have recently obtained a foothold in the United States and are costing us large sums to deal with. During the meetings an interesting illustration of the distribution of scale insects came to light. The Chinese community gave a banquet to the delegates, and the tables were prettily decorated with green branches and flowers. Miss Alice Eastwood, the well-known botanist of California, who sat next to me, called my attention to some sprigs of *Aglaia odorata* which were infested by a white scale. I secured specimens and sent them to the U. S. Bureau of Entomology and the British Museum. Mr. Frederick Laing, of the latter institution, at once wrote me that they were *Aulacaspis fulleri*, a scale I had myself described from South Africa many years ago, and which had not been reported from any other region. It may have been in the Hawaiian Islands a considerable time, as it seems not to be very destructive. It is impossible to say in advance what insects will become major pests in a new country. Accidentally introduced without their natural enemies, they often spread almost unchecked, and any species of insect would soon overrun the whole world were there no obstacle to its multiplication. Thus we need to know the potential pests of all countries. For example, if a particular kind of insect is destructive, its near relatives are to be suspected as possible sources of trouble. It thus becomes highly expedient to revise or monograph the whole group concerned. This does not mean simply to sit down in a museum and describe the available specimens, as these will doubtless include only a fraction of the existing species. It means exploration and collecting, and the cooperation of entomologists in many countries. It means also proper facilities for publication. When a recently introduced insect gains a foothold, it is often out of the question to get rid of it entirely by poisons or gases or mechanical means. The sum of $20,000 appropriated to fight the camphor scale (*Pseudaonidia duplex*) in Louisiana did not prevent it from spreading into the wild country, where it is practically impossible to reach it. In such cases entomologists seek out appropriate natural enemies, which will pursue the pests everywhere, and while probably not exterminating them, will keep them in check. Where may those enemies be found? It is not always easy to say, sometimes a chance hint or record has

given a clue to their whereabouts. But it took Dr. Muir, who has a positive genius for this sort of work, some years to find the appropriate enemy for the beetle larva that was destroying the cane in the Hawaiian Islands. Not only may the desired discovery be long delayed, the crops suffering in the meanwhile, but it may never be made. Certainly it would not have been made in the case just mentioned had not Dr. Muir been extraordinarily persevering and sagacious, and the Sugar Planters' Association ready to back him up for a long period. Such a combination could not be expected to occur very often. But such work ought not to be thus haphazard. It ought to be aided and made relatively simple by a comprehensive knowledge of the enemies of injurious insects in all the countries bordering on the Pacific and all the islands of that ocean. This again means exploration and cooperation and publication. It accordingly appears that there is a very large entomological program arising out of the deliberations of the Food Conservation Conference. So large, in fact, that it will not be carried out in our generation; but fortunately it can be developed as rapidly or slowly as circumstances permit; every advance, no matter how small, being of some value.

Were it possible to establish barriers around the several countries, prohibiting commerce or travel, many dangers and difficulties might be obviated. No one advocates such a program to-day, nor indeed is it in any sense practicable. Furthermore, under such conditions the populations would be subject to periodical famine unless they were kept down to the numbers capable of being supported during poor years, perhaps with the aid of some accumulations from better times. Histories of antiquity are full of descriptions of such conditions, but to-day we hope to overcome famine through science and international cooperation. Commerce, so long as it is free, acts as a sort of insurance, because shortage will not occur everywhere at once. With international trade, under the continually improving conditions of transportation, the world can safely maintain a population many times greater than was formerly possible. This is only desirable if the people can be reasonably guaranteed those things which make life tolerable, and especially freedom from acute shortage of food. Unless we can definitely abandon the old methods of oppression and war, and all the burdens they impose even in times of peace, and substitute international commerce and intercourse, it is proper to advocate at once a considerable reduction in the numbers of mankind. Dr. P. J. S. Cramer, delegate from Java, put the matter graphically in telling me about his island. Rice is of course the staple food of the Javanese. But rice can not be grown except in the lowlands, and the population of Java now considerably exceeds that which can be supported on the local rice. This is no hardship because rubber, coffee and other products can be grown on the slopes and hills, and these find a good market, so that money is obtained to purchase more rice from elsewhere. But suppose the countries now exporting rice find they have not enough, or suppose something happens to rubber or coffee. Then there at once arises a serious, if not critical, situation. It may be met if conditions are fully understood in advance, but in the absence of proper knowledge, which also involves cooperation, disaster may be unavoidable.[4]

Another illustration of the necessity for international action was afforded by

[4] I was much interested, when on the way to Japan in 1923, to meet Viscount Akiro Toki, of the Japanese Department of Agriculture and Commerce, and to learn that he was returning from a mission to Europe, for the purpose of learning the best ways of baking bread and utilizing wheat as food. This is a good example of practical forethought in national administration.

the discussion of the locust problem, introduced by a paper sent by Professor C. F. Baker from the Philippines. As is well known, invasions of destructive locusts are the most terrifying manifestations of insect activity. In a few hours they reduce a prosperous region to a barren wilderness. Yet they can be dealt with if taken at the source and destroyed when young in the vicinity of their breeding places. These breeding places are usually far from the regions likely to be devastated and probably in some other country. They may well be in sparsely populated regions, which have not the means, had they the will, to destroy the little locusts. The only way out is again through cooperation, guided by the advice of expert entomologists, who must explore all the territory involved. Such examples may be multiplied almost indefinitely, showing that modern countries can not live by themselves, nor can they exist without utilizing scientific knowledge. Those who fancy that what was good enough for our ancestors ought to be good enough for us should remember, first, that we are enormously more numerous than those ancestors; and, second, that while modern transportation is necessary in the modern world, it creates new difficulties of the most serious character which must be overcome.

One of the difficulties, quite unrelated to entomology, was brought before the conference by Dr. B. W. Evermann. He described the fearful destruction of birds and marine life, and the pollution of beaches, by oil thrown out from vessels. It is a world-wide evil; I have noticed the effects on the coast of England. It appears that methods can be adopted to prevent the spreading of oil on the sea, but only international agreement will compel shipping to conform. Individual countries are relatively helpless, but the need for action is so great that it surely will not be long delayed.

The resolutions passed by the conference were framed in the several sections and then presented in open meeting. They number thirty-three, of which the following are perhaps most significant:

IV. Among other things, strongly supports the plan for a Pan-Pacific Information Bureau that may have branches in various cities and collect and distribute accurate information about all the countries about the Pacific.

VII. Asks the Pan-Pacific Union to form a committee of men versed in International Law to form a Pan-Pacific Bar Association, in order that legal advice may be available in framing international agreements.

VIII. Commends the action of Messrs. George and William Castle in offering a home for the proposed Pan-Pacific Research Institute, and urges support for the project. The fine house and grounds given by the Messrs. Castle are in the Manoa Valley, and were visited by the delegates during the conference. The project is going forward with the cooperation of distinguished scientific workers, and bids fair to develop into something of first-class importance. It is to be strictly Pan-Pacific, that is, international.

IX. Recommends uniform weights and measures, preferring the metric system.

X. Asks that important scientific and technical publications, in the Pacific area, when not published in English, shall present English abstracts.

XII. Urges support for international scientific abstracts.

XVIII. Advocates international control to prevent pollution of the sea.

XX. Urges steps for the protection of sea turtles. XXI similarly deals with marine mammals.

XXIII. Asks support for the study of the marine life of the Pacific.

XXIV. For an International Crop Protection Committee, dealing mainly with insect and fungus pests.

XXV. Refers to the important results obtained by the use of the natural enemies of insect pests, and urges the training of men capable of working in this field, and the establishment of permanent stations for entomological and phytopathological investigations.

XXVI. Supporting general biological investigations throughout the Pacific.

XXVII. Deals with the locust problem.

XXVIII. Urges uniformity of quarantine regarding live stock, to be obtained through a joint commission.

XXIX. Calls attention to the importance of exact information concerning the conditions and possibilities of rice-growing.

XXX. Relates to soil surveys.

XXXI. Recommends official (uniform) grades and standards for rice, present practices being misleading and confusing. XXXIII has to do with the general problem of uniform commercial standards.

XXXII. Asks nations to publish crop forecasts and statistics of food production and consumption, in order to stabilize and guide the actions of all countries.

It will readily be seen that we have, growing out of the brief sessions of the conference, a comprehensive program for social advancement and for the abatement of many evils. No one expects to see all this realized in the near future, but for representative men to meet and agree, and carry home the message of inspiration and hope, is at least a matter of some consequence. All reforms and advances have some small beginning, and although others will doubtless receive credit for carrying out various portions of the above program, the work of the Food Conservation Conference will probably appear more significant in the pages of history than it does at the present time.

Various arrangements were made to emphasize the international character of the gathering. The flag ceremony, when the Governor of Hawaii stood on the steps of the Iolani Palace and received the flags of all nations and states represented, was a beautiful and inspiring affair. United States Infantry and marines formed a guard of honor on each side of the driveway, and the U. S. flag was dipped as the others went by. The bearers of the flags were suitably dressed young women or boys, making the ceremony as interesting and attractive as possible. There was a large crowd, and Governor Farrington was surrounded by the most distinguished people then in the island.

During the conference the various communities in the island gave banquets or other entertainments for the delegates. Thus we were received by the Hawaiians, Japanese, Chinese, Koreans and Filipinos. Although these various racial types keep distinct in the islands, they are taking advantage of the conditions created by the Americans and appear to get along together surprisingly well. In this respect the Hawaiian Islands perhaps bid fair to duplicate the conditions in Switzerland. The political problem at the present time is a complex and difficult one, and I did not attempt to study it with any care.[5] It seems to be recognized that there will be a greater development of practical democracy, and that the Hawaiian-born Japanese, growing up, will have an increasingly large part in public affairs. Making all possible allowance for criticisms, it seems that on the whole the islands present a most striking and hopeful experiment in racial cooperation. If administered in the spirit of the Pan-Pacific Union, they should go forward to a very happy future.

At the close of the meetings there was held a farewell banquet, at which short speeches were made by representatives of the various nations. Although we refuse to recognize Russia politically, Siberia is in good standing with the Pan-Pacific Union by virtue of its place on the Pacific. No actual delegate from that country being present, I was asked to speak on behalf of Siberia, which I did with pleasure. At the next conference there will doubtless be Siberian delegates.

The next conference, to be known as the Third Pan-Pacific Science Congress, will be held in Japan in the autumn of 1926. It may be, and must be, a tremendous influence for good. Let us support it in every way, and with the cooperation of the Japanese, do our part to permanently establish peace and good will as the rule of the Pacific.

[5] I was present at a demonstration of Filipino sugar-cane laborers at Hilo, Hawaii. They were striking for better conditions and I learned that there was widespread discontent. Yet in Kauai I was surprised to see the evidences of general prosperity, as shown by the appearance of the people, their homes, their many automobiles, etc.

# RADIO TALKS ON SCIENCE[1]

## THE PRESENT PREVALENCE OF CERTAIN DISEASES

By Dr. VICTOR C. VAUGHAN

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MEASLES is now unusually prevalent in all parts of the world. It is highly desirable that this disease should be recognized in the preeruptive stage. Uncomplicated measles is not highly fatal, but it predisposes to a form of pneumonia which is highly fatal. When there is adequate medical inspection, it is best not to close the schools on account of an epidemic of measles, but all children should be inspected daily. A skilled physician is able to detect measles, in the majority of instances, in the preeruptive stage; then the child should be isolated, kept in bed, and the younger children exposed, especially those under one year of age, should be treated with the serum of a convalescent. Strict isolation, even from other cases of measles, is required. When many cases of measles are kept in the same room or ward, one may carry a virulent pneumonia organism and may transmit it to others. One attack of measles gives lasting immunity. Adults who have never had the disease are as susceptible to it as children. In the treatment of measles life depends largely upon the prevention of the development of pneumonia.

Influenza has shown a tendency to increase in frequency and virulence during the past two or three months; this is evident in both hemispheres. However, no great pandemic of this disease is probable at the present time. The increase will continue with variations until warmer weather comes. The cause of influenza has not been definitely ascertained; there is no vaccine and no specific treatment. Unlike measles, one attack of influenza does not confer lasting immunity. Success in the treatment of this disease depends upon early recognition, isolation and rest in bed. Special attention should be given to the sterilization of tableware, cups, knives, forks, spoons, etc. "Hand to mouth infection" is recognized as an important factor in the distribution of the disease. Uncomplicated influenza is not a deadly disease, but, like measles, it predisposes to a highly virulent pneumonia. Influenza comes in waves and is most severe in cold weather, although it may be highly fatal at other seasons. Judging by the past, a pandemic of this disease will come sooner or later. There is, however, at present no basis for a prediction as to when this will come. At present every bad cold should be suspected and the victim should isolate himself and keep in bed.

Scarlet fever has not shown any increase in virulence for some years past and continues, for the most part, to be of the mild type. In 1924 an antitoxin for this disease was discovered and its value has been tested since that time. There are three stages in the development of scarlet fever: in the first, the organism grows superficially and produces its poison, which is absorbed; in

[1] Broadcast from Station WCAP, Washington, D. C., under the auspices of the National Research Council and Science Service and the direction of W. E. Tisdale.

the second stage, the germ penetrates the tissue and continues the production of its poison; in the third stage, other germs, as well as the specific one, have penetrated the tissue and are elaborating their own poisons. The antitoxin is of great value in the first stage, acting almost with certainty in arresting the disease. It is of less value in the second stage and of but little worth in the third stage. Here, as in most infectious diseases, early recognition and prompt treatment are the factors upon which reliance must be placed. When we remember the disasters in the loss of speech and hearing, which so often follow scarlet fever, we should regard it as a most serious disease.

Smallpox is of two forms, mild and grave, and each is inclined to breed true. The virus of this disease has not been clearly identified. There is, however, a vaccine which, when properly used, guarantees protection. The one vaccine protects against both kinds of smallpox and the protection secured by vaccination and revaccination is even greater than that induced by one attack of the disease. Smallpox prevails where and when vaccination is neglected. When vaccination is compulsory and is strictly enforced, there is no smallpox. There were nearly ten times as many cases of smallpox in the United States in 1925 as there were in Russia. In most continental European countries in 1925 there were no cases of this disease. In England, where vaccination was discovered, there were, in 1925, about two hundred cases, while in twenty-seven states in our own country there were, during the four weeks ending December 26, 1925, 1,326 cases, while in the whole of Russia during the same time there were not more than 150 cases.

Poliomyelitis, or infantile paralysis, has been on the increase in this country each summer for the past three years, and unless something is done to prevent it, we are going to have marked epidemics of this disease. For the seven weeks ending July 18, 1925, thirty-two states reported 462 cases, while for the year before, during the same time and in the same states, there were 121 cases. During the first half of the year 1925, California reported 154 cases; New York, 66; Minnesota, 46; New Jersey, 35, and Illinois, 20. Besides these there were sharp outbreaks in South Carolina in April, 1925, and the same occurred in Louisville, Kentucky, and adjoining cities later in that year. We are still quite ignorant of the cause of this disease and how it is disseminated. Experts should be sent wherever infantile paralysis is reported and thorough investigations should be made.

Asiatic cholera was not reported in the Western Hemisphere in 1925, but there were outbreaks of this disease at maritime ports in China, Siam, Japan and the Philippine Islands. By the close of the year all these, with the exception of those in Siam, had been eradicated. In India, where cholera is endemic, the number of deaths from this disease in 1925 was about one half of what they were in 1924. During 1925 this disease was entirely absent from the central provinces and from the city of Bombay. Cholera has been entirely suppressed along the Volga and throughout Russia. At the close of the year 1925 there were still cases in Calcutta, Madras and Bangkok.

Typhoid fever decreased in all European countries during 1925, but increased slightly in the United States. This increase was partly due to shellfish infection, but there were water-borne outbreaks also. The people of this country, including health officials, seem to think that we are practically done with typhoid fever. In my opinion, this is not the case. We depend largely upon chlorination for the destruction of the typhoid bacillus in our drinking water, but there is a limit beyond which this can not be carried. Typhoid vaccination

of civilian population has been practised in North Carolina with success.

Typhus fever, which is spread through the agency of body lice, has rapidly receded in Russia, Poland and Czechoslovakia. Not only are the cases less numerous, but the types seem to be milder. This indicates that the people in the regions mentioned are giving more attention to personal hygiene and are freeing themselves from vermin.

Yellow fever is apparently extinct in the Western Hemisphere. There has been no yellow fever in Central America since October 22, 1923, when a small outbreak appeared in Salvador. All other countries from Mexico to Chile have been free from this disease for a much longer period of time. Turning to Brazil, there have been no cases in the large cities for two years, and the last case reported in a village back of Bahia was seen by Dr. Joseph White, expert for the International Health Board, and pronounced by him not yellow fever. Omitting this one, the last death reported from yellow fever in the Western Hemisphere occurred in May, 1925. Before the Panama Canal was completed, epidemiologists expressed fear that yellow fever might be transmitted from Central or Western South America to the Orient, but this danger has been wholly removed by the eradication of the disease from these regions. Yellow fever has been reported, and is still being reported, along the west coast of Africa. The International Health Board has sent a commission to investigate this matter and this commission arrived at Lagos, Nigeria, in June, 1925. The purpose is to determine whether the disease reported is yellow fever, and, if it is, to stamp it out. If it be found that yellow fever is actually endemic in Nigeria, its elimination will be a problem of world-wide importance. Railroads have been planned and in part have been built over the high plateau of Central Africa, and a disease prevalent in Nigeria may easily reach the east coast and from thence take passage to the Orient, where the Stegomyia (the mosquito involved) in great numbers awaits its coming and will not delay in its transmission.

Human plague was reported during 1925 in only two ports in the Western Hemisphere—one on the west coast of South America at Guayaquil and the other on the east coast at Bahia. In both of these localities strenuous efforts are being made to exterminate the rats, which are the harbingers of the flea which transmits this disease. In India there has been less plague than during any year since 1899. There have been a few cases in Mediterranean ports, one at Beirut and one at Patras. Early in the year there were a few cases in Egypt, but there have been none during recent months. People all over the world are apparently making strenuous efforts in their contest with rats.

It will be understood that rat plague is much more widely distributed than human.

Tuberculosis shows a gradual decline over the greater part of the world. There has been no noteworthy discovery in the treatment of this disease. Late in 1924 a Dane announced a cure, but he has not been able to substantiate his claim.

Malaria is gradually receding in this country towards the Gulf of Mexico. Forty years ago the malarial belt extended to the Great Lakes and protruded over large areas in the New England States. This recession is due largely to the reclamation of drainage of land for agricultural purposes, thus eradicating the breeding places of the Anopheles mosquito. At first this was due solely to economic interests and its value as a health measure was first appreciated about twenty years ago. The prophylactic employment of quinine, of screens and of mosquito exterminators, such as small fish, is now recognized. In nearly every part of the world antimalarial

measures, largely influenced and directed by the International Health Board, are in operation. We can optimistically look forward to the time, if science meets with no setback, when the tropics, containing the most productive areas of the world, will become the great seat of civilization. The malarial belt in Russia is rapidly receding. Soon after the war it reached Archangel, the highest point north ever known to have been reached by this disease. Malaria is still more or less prevalent along the Volga, but is gradually receding southward. There are spots in Russia where the prevalence of this disease continues to be high, but even the Soviet government seems to be appreciative of health measures.

Hookworm infestation is also gradually receding again under the influence and operation of agencies supplied by the International Health Board. Even the inhabitants of Central America and those of the South Sea Islands are building model latrines.

Encephalitis lethargica, ordinarily known in this country as sleeping sickness, but quite distinct from the sleeping sickness of Africa, has apparently revealed its causal agent to the researches of Miss Evans, of the United States Hygienic Laboratory, and Dr. Freeman, of St. Elizabeth's Hospital. As early as 1917 a doctor in Vienna found in the brain of a patient who died from this disease a micrococcus, but, of course, whatever this doctor might believe, he could not claim that he had discovered the causative organism, since he had found it in only one case. Miss Evans and Dr. Freeman state that they have succeeded in inoculating rabbits with this organism and transmitting the disease through a series of fourteen animals. They state that their find appears like a common streptococcus.

Dengue, a most distressing but not highly fatal disease, widely prevalent in tropical and semi-tropical countries, is distributed by a mosquito. This was demonstrated many years ago by an American physician, Dr. Graham, then a teacher in the medical school at Beirut, Syria. However, Dr. Graham was not sure about the species of mosquito which he employed in his experiments. Recently this has been determined by a board of medical officers working in the Philippines and they find that dengue is transmitted by the Stegomyia, the same mosquito which distributes yellow fever, and not by Anopheles, the malarial mosquito, nor by the Culex.

Leprosy, now well provided for at the National Leprosarium at Carrville, Louisiana, continues to supply sporadic cases —thirty-six in 1924 and thirty-eight in 1925.

Cancer, so far as treatment is concerned, still lies in the hands of the surgeon, and those who have any suspicious growth should immediately consult him.

Goiter, certain forms at least, as was shown a few years ago, is due to the absence of iodin in our food, drink and the air which we breathe. As soon as this was demonstrated, the food manufacturer, ever ready to glean the coin which may be gained by the application of scientific discoveries, got busy and, among other things, flooded the market with iodized salt. This is already doing harm. It should be understood that there are different kinds of goiter and all kinds are not prevented, or, being present, are not benefited by medication with iodin. Moreover, it should be understood that the dosage of iodin in the prevention or in the treatment of goiter is in milligrams and not in grains, and that there are sixty-four milligrams in one grain. The maximum dose of iodin in the prevention or treatment of goiter should be ten milligrams or about one sixth of a grain daily for not longer than one month. The wholesale use of medicine of any kind or chemicals of any kind by the people without medical supervision is fraught with danger.

In my opinion, the time has come when

epidemics may be predicted with as much certainty and at no greater cost than the weather is now forecast, and, what is more important, when epidemics are foreseen, they may be prevented, and this does not apply to the weather. The newspaper of the future will carry on its front page a condensed health report much as it now carries a similar weather report.

# NEW RIGID AIRSHIPS

By STARR TRUSCOTT

BUREAU OF AERONAUTICS, NAVY DEPARTMENT

THE House Committee on Naval Affairs recently recommended to Congress the construction of two large rigid airships.

The proposed airships are to be of six million cubic feet capacity. This is about three times the volume of the *Shenandoah*, but the length will be only about 15 per cent. greater, and the diameter about 50 per cent. greater. The intention is to provide the best ship which can be built at the present time. The authority recommended is in line with the old-established naval policy which calls for quality first and quantity second. It will not give a large number of airships, but it will give two very *good* ships.

The Navy began to study rigid airships intensively in 1917. Then this country had practically no knowledge of the science of rigid airship design or of the materials and art of construction. Once begun, study and experiment have never stopped. Everything that could be learned from others has been obtained. The *Los Angeles*, a ship of the best and latest design, has been obtained from the German firm which built more than one hundred successful airships. The best design, construction and operating personnel of that concern have been brought to this country and are now available for aiding in the further development of rigid airships in the United States.

No other nation has so intensively continued the study of the various parts of the rigid airship problem or has done so much work on them. We now have more information regarding rigid airships at our disposal than any other nation. The action of the committee was, therefore, peculiarly timely.

I am not going to describe a rigid airship, but I want to recall to you that a rigid airship has a rigid structure for maintaining its form and sustaining the various loads impressed upon the ship as a whole. The gas is contained in a number of independent cells and the airship usually has several sets of propellers and engines.

The principal things which we must know—and have—to design and build a successful rigid airship are:

(1) The airpressure—or aerodynamic—loads on the ship as a whole while in flight.

(2) How the aerodynamic and weight loads are distributed in detail to the individual members of the structure.

(3) Satisfactory materials from which to make the members of the structure.

(4) Satisfactory materials from which to make the gas cells to contain the buoyant gas.

(5) Engines which have sufficient power combined with lightness and extreme reliability.

There are many other things, of course, but these are the most important.

The influence of the form of the airship and of the fins and rudders on its resistance to passage through the air and on the loads sustained by the ship is important, and a great deal has been learned from experience and research. Part of this has come from the wind

tunnel where small models of the airship —reproducing the full sized ship as completely as the scale will permit—are suspended in such a manner that the observers can determine not only the resistance to being driven through the air —or drag—but also how effective the fins and rudders will be in keeping the ship on her course. In the wind tunnel the model is held stationary by the indicating mechanism and the air moves by it, just reversing the condition with the real ship. Before a particular form is adopted it is tested in the wind tunnel in comparison with other forms.

Once the form of the hull and the position and size of fins and rudders has been decided we can begin to estimate the loads it will encounter in the air. This is possibly the most difficult problem of all.

Nearly every one has at some time walked or ridden across one of the old wooden covered bridges which may still be found in some sections. These bridges were usually built by bridge carpenters. The loads in the various members of these bridges were not accurately known or determined, but the size of timber or iron was determined by the success or failure of previous bridges, and this information was handed down from father to son.

When you ride over a modern bridge in your automobile or on a train the load which you and your vehicle throw into each piece of the structure—steel or concrete as the case may be—can be determined very exactly by the designer.

A few years ago the design of the structure of rigid airships might have been said to be in the old covered bridge period. To-day we have arrived at the steel and concrete bridge period.

The loads from the weight of the structure of the ship itself and from passengers, fuel and cargo are fairly easy to determine. Those imposed by motion through the air are not so easy.

A few years ago we could only reason that if a certain airship, whose design was known to us, had flown and withstood successfully certain combinations of speeds and maneuvers with certain cargo loads, another somewhat similar system of speeds, maneuvers and cargo loads—stepped up according to the size —could be used in the design of a new airship.

Recently we have gotten away from this method. One of the first steps was to measure the actual air loads at various points over the surface of an airship, including the surfaces of the fins and rudders. The first comprehensive test of this sort was made by the National Advisory Committee for Aeronautics on the Navy non-rigid airship C–7 a few years ago. The airship became a flying research laboratory, and the scientists taking observations flew day after day to get the readings required. Unfortunately this ship was not so large or fast as was desired and the results—while helpful—were primarily of value in telling just what points should be investigated in detail on a large rigid airship. Accordingly a similar and more extensive program will be carried out on the *Los Angeles*, and she is now being fitted with the necessary apparatus. Next month the *Los Angeles* will begin a series of maneuvers intended to duplicate everything that may be expected of her in actual service. She will be flown at various speeds and made to turn from her course with varying degrees of suddenness. She will be flown inclined upward by the bow and downward by the bow and swung around in circles. To describe the program in detail would be wearying. What is important is that throughout each maneuver the observers will make records at regular intervals showing exactly what the air pressures—and consequent air loads—are over the body of the ship and the fins and rudders. While these air pressures are being determined there will also be de-

termined the actual loads which the air pressure loads on the ship as a whole are producing in the principal members of the structure of the ship.

This far-sighted policy of the Navy in using the *Los Angeles* as a laboratory for obtaining scientific data for the design of larger airships and for the training of personnel, is certainly to be commended. The information and data obtained from the tests made on the U. S. S. *Los Angeles* will be most valuable, in fact indispensable, in developing the new design. No country in the world has as yet built and completed an airship of six million cubic feet capacity, although England is building two of five million cubic feet capacity each.

There are several theoretical methods which can be used to estimate the individual loads in the various girders and wires of a rigid airship. Five years ago the best theoretical methods available gave results so far apart that it was difficult to select which should be used. Since then we have improved our theoretical methods and have developed accurate and practical checks against them. One check is to measure the loads carried in the various girders and wires while the ship is actually in flight, as will be done on the *Los Angeles* in connection with the pressure distribution tests.

Another method uses a large model in which the girders of the full-sized ship are represented by bars of celluloid and the wires by fine steel wires. This model is loaded by weights applied to simulate the loads of actual service. The members take up and distribute their loads like the girders of a full-sized ship. This distribution is determined by actually measuring them in each member. These measurements are truly scientific measurements made by using methods originally developed by the scientist for other purposes. By using such a model an airship structure of a new type can be tested, and the best arrangement of parts determined, at a very moderate expense.

Scientific research has given us several materials from which to build the girders of our new ships. Probably duralumin, the alloy of aluminum, copper, magnesium and silicon which was used in the *Shenandoah* and *Los Angeles*, is the most practical at present. It has about one third the weight and about the same strength as structural steel. This gives parts having good thicknesses and in which substantial riveted joints can be made.

There has recently been quite a to-do about the corrosion of this material. Corrosion is simply another name for rust. Every one knows that steel usually rusts, but it is not thought mysterious. Duralumin also rusts, but under the same conditions it rusts much more slowly than steel. In thin pieces even a little rust may be serious, but we have every reason to believe that before this year is out we will have demonstrated that it is possible to prevent even the slower rusting of duralumin by the same general methods as with steel.

For ships of even larger size than six million cubic feet capacity, we consider the use of the newly developed so-called "stainless steels." Most housewives know this material in the form of knives. It does not stain after use with certain fruits and vegetables and rusts very slowly. These steels can be made so much stronger than the ordinary ones that in large girders the advantage of duralumin may disappear. However, it surely will remain in smaller ones where duralumin for the same weight will be three times as thick, and much easier to work with.

During the construction of the *Shenandoah* 150 girders—exact copies of those on the ship—were tested to destruction at the Bureau of Standards. Girders for the new ships will be designed according to the information thus

obtained and will be similarly tested to prove their strength.

The gas cells of the *Shenandoah* and *Los Angeles* were made of goldbeater's skin fabric, consisting of a light but strong cotton cloth to which was cemented a layer of goldbeater's skin. These skins—one of the layers of a part of a stomach of the ox—are very costly. They measure at most only 15″ x 40″ and must be laid with 1″ overlaps all round. So the statement that 500,000 cattle died to supply the linings for the gas cells of the *Shenandoah* is probably not exaggerated.

Chemical research is now preparing sheets of synthetic films which are much cheaper than goldbeater's skins and promise to be not only as good for the retaining of gas but even better.

Helium, our inflation gas, is a triumph of the physicist and chemist. The natural gases from which it is extracted contain less than one per cent. of helium and to get the two and one half million cubic feet of helium required to inflate the *Los Angeles* the plant at Fort Worth must handle about three hundred million cubic feet of natural gas. Yet helium now costs us only three and one half cents a cubic foot. Only ten years ago it would have cost—if you could have persuaded some one to let you have that much—at least fifteen hundred dollars per cubic foot. The cost is being reduced by each new improvement in the processes.

Few people realize what a unique advantage has been given to us in the possession of this helium supply. Any one —after careful trial and study—can imitate and possibly improve on any of the products of our brain or shop, but so far no nation has found a supply of helium comparable to ours. With the danger of fire from the ignition of the inflation gas done away with, we can do many things that others can not do and thus, we hope, produce superior airships.

Every one has followed the wonderful success of our aircraft engines. Here chemist and physicist have joined hands to give great power with light weight and reliability. American aircraft engines are the finest built to-day.

Germany, Great Britain and the United States have all together and to date completed about 150 rigid airships. Most of these were very successful, although constructed without the aid of the much more accurate information which we now possess. If these earlier ships could operate successfully under those circumstances and without the use of helium you can see why the continued study which has been carried on for these past years by the Navy Department has placed us in a position to proceed with the design and construction of new rigid airships with full confidence in their success.

# "SEEING" WITH X-RAYS

By Professor F. K. RICHTMYER

CORNELL UNIVERSITY

No scientific discovery in the last half century has had a wider application, in both pure and applied science, than have X-rays. By means of X-rays your dentist can decide which tooth to extract, rather than to extract several in order to find which one was ulcerated. The physician can see the break in the bone almost as clearly as if the bone were freed from the surrounding flesh. Further, he can study the development or arrestment of such diseases as tuberculosis and mastoiditis. He can investigate certain disorders in the digestive tract.

And indeed he finds in X-rays a tool which has revolutionized certain phases of diagnosis and treatment, and which, during the war alone, saved thousands of lives. The engineer uses X-rays to give him very valuable information with regard to the properties of materials which he uses in making bridges, automobiles, airplanes, filaments of incandescent lamps, electrical equipment and a thousand and one other things. By means of X-rays the crystallographer has vastly extended his knowledge of the way in which atoms are piled together to make up crystals, such as snowflakes, diamonds and ordinary table salt. And, most fascinating of all, the physicist has used X-rays to construct what one might, without too great a stretch of imagination, call a super-microscope, by means of which he can study the architectural make-up of the ultimate constituents of matter, *i.e.*, molecules and atoms. It may be interesting, therefore, to say a few words about the origin and development of this wonderful agency of modern science.

In the autumn of 1895 Wilhelm Conrad Röntgen, a German scientist, was experimenting in his laboratory with that very fascinating phenomenon, the passage of electricity through the rarefied gas in a partially evacuated glass tube. Accidentally and very unexpectedly he discovered that there proceeded from that part of the glass wall which was struck by the discharge an entirely new type of radiation which was like ordinary light, in that it travelled through the air in straight lines, affected a photographic plate and caused fluorescence; but which differed from ordinary light in that it could not be reflected by a mirror or refracted by a prism. And most surprising of all this new radiation was able to pass very easily through substances opaque to ordinary light, such as black paper, wood, thin sheets of metal, etc. Bones were more opaque than flesh, and hence cast a deeper shadow on the photographic plate, a circumstance which made possible the well-known X-ray picture. Röntgen made a guess that this new radiation was just like light, except that it was composed of much shorter wave lengths—just as the sound from the high notes of the piano are of shorter wave length than that from the low notes. Later investigations have shown that Röntgen was right. X-rays are light waves of very high frequency—approximately one thousand to ten thousand times that of ordinary light. (The highest note on your piano has a frequency approximately 150 times that of the lowest note.)

X-rays are produced in a highly evacuated tube, usually glass, by causing swiftly moving electrons coming from a heated filament such as you have in your radio tubes to be suddenly brought to rest by colliding with a solid body, such as platinum or tungsten, usually called the target. A simple analogy will illustrate the process. Imagine a tin pail full of bird-shot suspended from the ceiling of your room. Immediately beneath the pail put a tin pan bottom side up. Drill a small hole in the pail and allow a fine stream of shot to fall upon the pan. The sound which you hear—a mixture of two distinct parts, the characteristic note of the pan and a mere noise—is, in a rough way, the acoustical analog of a beam of X-rays. The pail corresponds to the filament, which when heated gives out electrons. These, in turn, correspond to the shot. The tin pan corresponds to the target of the X-ray tube. And the force of gravity pulling the shot downward corresponds to the electrical field which is applied between the target and the filament to accelerate the electrons so that they strike the target at high speed. A beam of X-rays, just as in the case of the sound from the tin pan, is composed of two parts, one which is characteristic of the material of the target, and the other which depends on how hard the electrons strike the target.

In scientific research, just as in exploration, an unexpected discovery proves of far greater value than the original quest. Columbus accidentally ran upon America in his search for a new route to the East Indies. Had Röntgen, in 1895, been seeking some device to assist the surgeon in setting broken bones, it is almost certain that neither he nor any one else would have thought of experimenting with electricity and evacuated tubes.

Indeed, so common are these unexpected things in science that one is inclined to question the general validity of the old saying, "necessity is the mother of invention." Sometimes, to be sure, it is true. It was not necessity, but rather scientific curiosity that urged Michael Faraday, a century ago, to experiment with electricity and magnetism, and thus to discover the fundamental principles which to-day make the electric motor and dynamo possible. Dynamos and motors became necessities long after Faraday's discoveries.

Accordingly one feels justified in saying that, valuable as are the applications of X-rays which are being made by the surgeon, the physician and the engineer, of still greater value, because of the fundamental discoveries which may grow out of them, are the experiments which the scientists are making with and by means of X-rays. You may be interested in some of the results.

After the radio program this evening sprinkle a few grains of table salt on a piece of black paper and examine them with a pocket magnifying glass. You will observe that many of the grains are little cubes, or, we might say, cubical crystals. The chemist tells us that this salt, which is such an indispensable article of our diet, is made up of atoms of two elementary substances or elements, sodium and chlorine, neither of which, alone, we should find very palatable. By a variety of physical and chemical methods the number of atoms in one of these crystals can be determined with high precision. Thus a cubical crystal of salt one centimeter (four tenths of an inch) on an edge, contains a number of sodium atoms which you can express by writing down the figures 224 followed by twenty ciphers; and an equal number of chlorine atoms. In spite of the fact that these atoms are very small—about a billion of them side by side would make a row an inch long—there are so many of them in one cubic centimeter of rock salt that if arranged in a single row, instead of in a cube, they would make a line twice as long as the diameter of the earth's orbit. Truly, an atom is far too small ever to be seen by the most powerful microscope.

But let me ask you a question: Did you ever see the wind blow? Of course he who has ever seen the snow fly or the branches of trees wave will say yes. Now you didn't actually *see* the wind, for it is invisible. You really saw the effects of the wind. So accustomed are we to associate with the wind these effects of the wind that when we see them we say we have seen the wind. Many physical phenomena are likewise "observed," not directly but through their effects. Thus, no one has ever seen an electric current. Yet from its effects we have a fairly extensive knowledge of electricity. So, even if we can not "see" atoms in the ordinary sense, we can study them by indirect means, particularly by the aid of X-rays.

Accordingly, when we "look at" our crystal of rock salt by aid of a beam of X-rays, we see first of all that the atoms of sodium and chlorine are arranged in regular rows, columns and layers, like a three-dimensional checker board, in which a white square is always next to or immediately above a black square. It is this regular arrangement of the atoms that causes the crystal form and makes it possible to split the crystal along a cleavage plane. From certain electrical data the distance apart of these planes

is known, with great precision, to be .000,000,028,14 cm, and it is this fundamental distance which makes it possible to measure the wave length of X-rays. Studies of this kind show that a very great many substances are crystalline. Thus ordinary lime, calcium oxide, has a crystal structure like rock salt. Many metals, such as copper, gold, aluminum, platinum, sodium, tungsten, iron, have a cubical arrangement of their atoms, something like rock salt; while others, such as magnesium and zinc, have a hexagonal arrangement. It is by studying their crystal structure that the engineer gains valuable data regarding the property of his materials.

However, not only can the positions of atoms in crystals be determined with certainty, but X-rays have furnished one of the most important tools in studying the makeup, or structure, of the atom itself. We "see," first of all, that the atom is made up of electric charges, or perhaps some prefer to say, of charged bodies. There is a central core, or nucleus, containing a positive charge around which are negatively charged electrons, probably in orbital motion similar to the motion of the planets around the sun. Studies made with X-rays have made it possible to determine not only the number of those electrons, but with some probability their arrangement. Thus sodium has eleven electrons; chlorine has seventeen; silver forty-seven, and lead eighty-two. These electrons are arranged in concentric groups or shells. Thus silver has an inner group of two electrons, spoken of as the K group, just as if Mercury's orbit were occupied by two planets instead of one. Next comes a group of eight electrons, called the L group, similar to what we should have in our solar system if there were eight planets revolving in orbits the size of that of Venus. Outside the L group comes the M group, comprising eighteen electrons, as if there were eighteen earths. Then, probably, another group of eighteen with still larger orbits. This makes a total of forty-six electrons. The remaining electron, since silver has forty-seven, probably revolves in an orbit outside of all these and is the electron which the silver atom uses when it wishes to make chemical combinations, such as the silver bromide of your photographic film.

When the atoms in the target of the X-ray tube are bombarded by the high-speed electrons from the filament, the impact is sufficient to dislodge from their orbits some of the electrons which an atom normally contains, and thus the electron system is seriously disturbed. In the process of returning to its normal state by capturing other electrons to fill the vacant spaces, the atom radiates energy, *i.e.*, emits the characteristic X-rays previously referred to. A piano string, when disturbed from its normal equilibrium position by being struck with the hammer, emits sound waves.

By studying the frequency of these characteristic X-rays, we can gain some very precise information as to the energy required to pull an electron out of an atom and therefore the amount of energy which the atom gives out when it gets the electron back. It requires less energy to pull from the atom an electron of the L type than one of the K type; and still less for one of the M type. Accordingly, higher frequencies are given out when an atom regains equilibrium after having lost a K electron than after having lost an L electron. In the target of the X-ray tube some atoms lose K electrons, others lose L electrons, etc. Consequently we have from a given target material a large number of characteristic frequencies.

These amounts of energy, in the case of a single atom, are of course not large. But if there were some known means of extracting a single K electron from each of the atoms of silver in a ten-cent piece, the energy which would be given out when the ten-cent piece returns to nor-

mal by capturing electrons would be enough to run a twenty-five-watt incandescent lamp continuously for three weeks.

Perhaps our great-grandchildren may find a way to make use of this storehouse of energy, and if so they will have ample reason to be grateful to those scientists of our generation who have helped to acquire this knowledge and to build these theories which are now of such fascinating interest.

# WHAT IS AN ELEMENT?

By ROGER C. WELLS

UNITED STATES GEOLOGICAL SURVEY

For the benefit of any "listeners in" who may wish to know at once what I am going to talk about let me hasten to say that my subject concerns the chemical elements—not so much any specific chemical elements as the definition of an element and our reasons for classifying the elements by a series of numbers from 1 to 92.

To understand what is meant by a chemical element requires some idea of the scope of the science of chemistry. The chemist's particular field of study is the composition of matter of every sort—from the air we breathe to deposits dredged from the bottom of the sea. The chemist analyzes substances—that is, he separates them into simpler components. This sort of work has been going on for many years, but with all his separating he finds a few substances that he can not decompose into any simpler substances by ordinary chemical methods. These are the familiar chemical elements—the elementary substances of which all known matter is composed.

You will see that this view holds matter to be heterogeneous, even in its final analysis. But the idea that matter is more simple than this, that it is built up from a single substance, or at most from a few substances, is much older. The Greek philosophers have priority on this view, as they have on several other concepts in this field, such as atom, transmutation and chemical affinity. But their concepts were at best hardly more than suggestions, proposed with little or no experimental basis and bearing little resemblance to the ideas we now hold. On the other hand, like many other products of the fertile Greek mind, these earlier views have never lost their power to suggest questions and to incite investigators to put matters to a test and get at the root of things, so to speak.

Democritus, who lived about 400 B.C., was probably the first to think of the atom as the ultimate unit of matter, but it remained for John Dalton, over two thousand years later, to crystallize the idea by regarding the atom as a fixed weighable quantity of each element. The atoms of each element have a definite volume, called the atomic volume, and a definite weight, called the atomic weight. The atomic weights are of great assistance in calculating the proportions of elements in compounds and the proportions in which substances react chemically. For convenience, however, the atomic weights are expressed on a scale in which the atomic weight of hydrogen is taken as 1.[1] When the atomic weights of many elements were found to be exact multiples of that of hydrogen, Prout, another English chemist, suggested that all elements are really made up of hydrogen, and many determinations of the atomic weights of the elements have been made to see if they are exact multiples of any simple unit. A close approach to

[1] More precisely, the atomic weight of oxygen is taken as 16.

whole numbers is shown in a surprisingly large number of elements. The apparent exceptions are accounted for by the existence of isotopes, a word that will be defined in a moment.

The definition of an element as a substance that can not be decomposed into any simpler substance has been upset by studies of the radioactive elements. These elements decompose spontaneously. What the alchemist could not accomplish — transmutation — here appears as a natural process.

According to the usual definition of the chemist radium is an element, yet it decomposes into other substances which must also be recognized as elements. Some of these have very short periods of existence but their decomposition products prove that the atom must be composed in part of electricity or electrical energy.

Every one who uses electricity is familiar with the terms positive and negative. It is not so widely known, however, that the physicist, in considering electrical phenomena, thinks almost entirely of the negative electricity, and it is still less generally recognized, perhaps, that this kind of electricity consists of separate small units called electrons. The electron is the smallest entity known to science. It may be regarded as an atom of electricity, but its weight is certainly far less than the weight of even the lightest chemical atom and it is not generally considered one of the chemical elements. The equally small units of positive electricity that correspond to the negative electrons have received no special name.

Now the physicist has come to think of the atoms of the elements as composed, at least in part, of these units of electricity, as resembling, in fact, excessively minute solar systems with the units of negative electricity—the electrons—revolving in orbits about the positive centers, or nuclei. Some of the electrons may be located at the center, also, but a definite number are located in the exterior part of the atom, and the surprising relation appears that, beginning with hydrogen, the atom of which has only one exterior electron, the atoms of the other elements have two, three, four, and so on, up to ninety-two exterior electrons. Just as solar systems might be classified by the number of their planets, this relation furnishes a new simple numerical classification of the elements. The number of exterior electrons in each atom of any element is the atomic number of that element.

The atomic numbers of the elements are established by study of the X-ray spectra of the elements. Their order on this basis is, moreover, essentially similar to the order of the atomic weights, familiar to chemists as the Periodic System of the elements, by means of which the properties of scandium, gallium and germanium were predicted before the elements were discovered.

In the classification of the elements by their atomic number at least ninety-two seem to be possible, though the elements corresponding to numbers 85 and 87 are still undiscovered. Elements 43, masurium, and 75, rhenium, have been known scarcely a year; and 72, hafnium, not much longer. The existence of element 61, illinium, has only just been announced, as established by work done at the University of Illinois on its arc spectrum, its absorption spectrum and its X-ray spectrum. It is difficult to obtain these rarer elements in a pure state. You will see that spectrum analysis is an important method for differentiating and identifying elements. Some spectra are very complex, but this is not remarkable if the spectra are caused by rotation or vibration of the numerous electrons composing the different atomic systems.

As I said a moment ago, we now recognize ninety elements. But several of the elements thus defined appear in a number of forms that differ according to

their origin: such forms are termed isotopes. Thus element 82, lead, includes lead formed from uranium, ordinary lead, and thorium lead, whose atomic weights are 206, 207 and 208, respectively. No one has yet succeeded in separating these different forms of lead when once they are mixed, but they can be obtained separately from different minerals. The element chlorine, whose atomic weight is 35.46, has been partially separated into lighter and heavier portions, however, and it appears from the epoch-making work of Aston that many of the supposed elements are mixtures of isotopes, each isotope having an atomic weight that is a whole number on the present basis.

We therefore have two classes of elements—pure elements, each consisting of a single form, and complex elements, each consisting of a mixture of isotopes. The isotopes of the complex elements are not separable by ordinary chemical methods. Their chemical behavior is probably dependent on the number of the exterior electrons—that is, on the atomic number which is the same for all the isotopes of any given element. Differences in the atomic weights are probably explained by differences in the nuclei of the atoms.

It is only a comparatively short time since chemists held that the transmutation of one element into another would never be possible. The case is different now. Nature furnishes instances of transmutation in the radioactive elements and thereby discloses the most promising line of attack. It will be necessary to employ super-chemical means, in order to penetrate and break up the nuclei of the atoms. Already it is claimed that hydrogen has been made from nitrogen, gold and platinum from mercury, and mercury and thallium from lead. But up to the present these results if obtained have been obtained only at great expense, and transmutation for commercial profit is certainly not yet to be expected.

Studies with the spectroscope indicate that in some of the stars only a few elements of low atomic number exist. The temperature on these stars probably so far exceeds anything within experimental range on the earth that even the atoms of the elements are dissociated into the very simplest combinations. When such stars cool more complex elements are formed.

From this brief discussion I think you will see that we now define an element as a substance that consists of matter all the atoms of which have the same atomic number. The element may have one form or several, depending on the structure of its atoms, but the atomic number tells us with what element we are dealing. Now the elements have many other properties also. I could go on and show that when we list the elements in a series in the order of their atomic numbers some of their properties recur at regular intervals; other properties do not show such a recurrence. But time prevents my going further here. The periodic system of the elements will have to be another story.

# THE PROGRESS OF SCIENCE

## THE WASHINGTON MEETING OF THE NATIONAL ACADEMY OF SCIENCES

*Science Service, Washington, D. C.*

RECENT advances in atomic physics have led to a great increase in the understanding of internal conditions in the stars, Dr. Henry Norris Russell, of Princeton, reported to the National Academy of Sciences at its meeting on April 21. The outstanding problem is to find out where the heat radiated by the stars comes from and in what manner heat is liberated inside the stars. We now know that inside a star the atoms have their outer parts knocked off, but retain their individuality. And it is possible to calculate at what rate heat should escape from the interior to the surface, and therefore how bright the stars should be, if we know how large and massive a star is and how much denser it is in the interior than at the surface. Existing evidence indicates that heat is probably produced by a slow transformation of matter into energy, after the manner first suggested by Einstein. If all stars were composed of exactly the same material, stars of the same mass would be similar, not only in brightness, but also in size, color and temperature. This is not a fact, and it follows that some stars must contain more than others of the "active material" which is the source of heat. The life history of a star depends upon the proportion of active material in its composition. If, as seems probable, this originally forms the larger part of the star's mass, a star of large mass will start as a red giant, gradually become hotter and whiter, and finally cool down and end as a faint dwarf. Stars of smaller mass may begin their careers as dwarf stars without ever passing through the giant stage.

METHODS of measuring and weighing stars so distant that their light takes hundreds of years to reach us were described by Professor Joel Stebbins, director of the Washburn Observatory of the University of Wisconsin. Observations with the spectroscope reveal motions of certain stars which can be explained by their having large companions or planets. The periods of revolution of many of these attendant bodies are very short, even as small as one or two days. By choosing the proper time for light measurements, it is found that among the cases known in advance to be favorable fully one half of these double systems present eclipses as viewed from the earth. A study of the variation of the light of a star during an eclipse makes it possible to calculate the diameter of both the bright star and its dark or faint companion. As an illustration, it is noted that two stars moving in space parallel to the stars of the Big Dipper, and presumably belonging to that system, have each been found to have attending satellites. Each of the bright bodies is twice as heavy and gives one hundred times as much light as our sun.

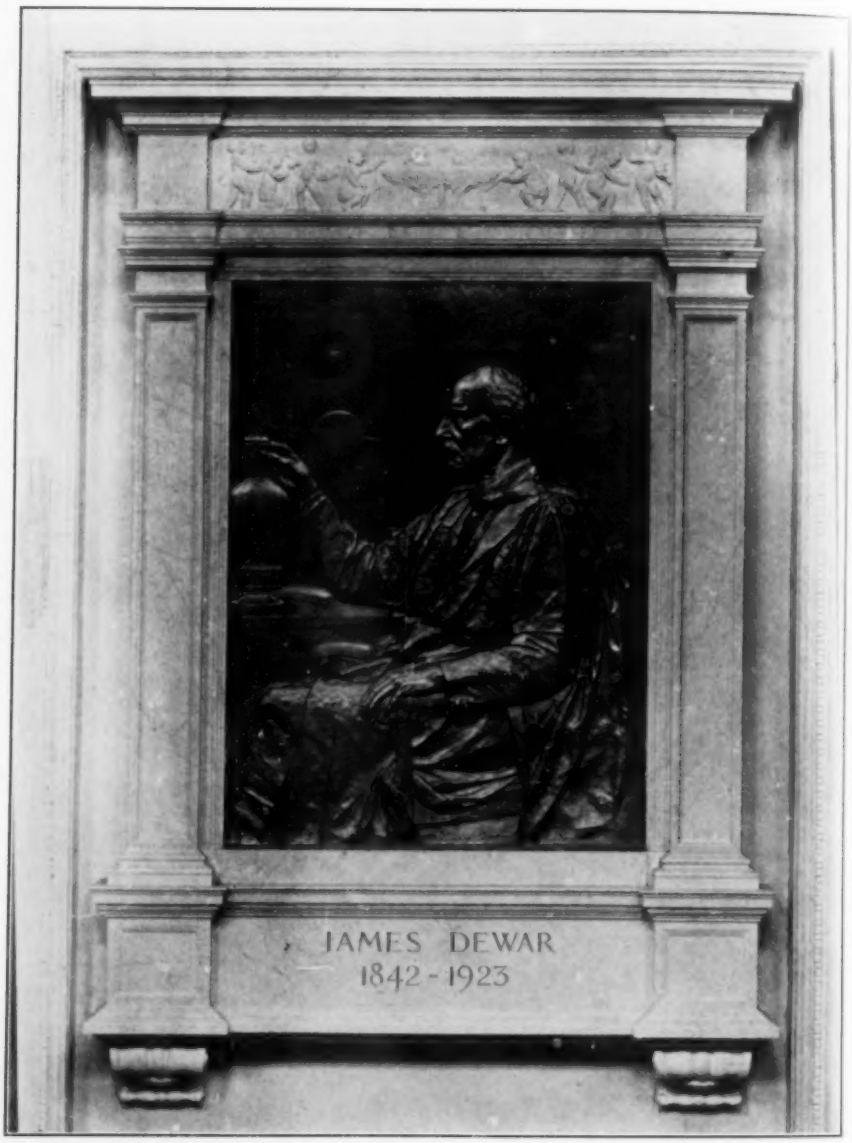
MOTION of stars through space is not a random hit-or-miss motion, like a swarm of gnats, but many stars are moving along in parallel streams. In fact, such star streaming is a common phenomenon, according to a paper presented by Professor Frank Schlesinger. The Yale Ob-

DR. WILLIAM BERRYMAN SCOTT

BLAIR PROFESSOR OF GEOLOGY AND PALEONTOLOGY AT PRINCETON UNIVERSITY, 1884, WITH THE HAYDEN MEMORIAL MEDAL AWARDED TO HIM BY THE ACADEMY OF NATURAL SCIENCE, PHILADELPHIA.

DR. HARVEY CUSHING

MOSELEY PROFESSOR OF SURGERY IN HARVARD UNIVERSITY AND SURGEON-IN-CHIEF OF THE PETER BENT BRIGHAM HOSPITAL, TO WHOM HAS BEEN AWARDED THE PULITZER PRIZE FOR HIS "LIFE OF SIR WILLIAM OSLER." THE PHOTOGRAPH WAS TAKEN IN FRANCE, WHERE DR. CUSHING WAS COLONEL IN THE MEDICAL CORPS OF THE UNITED STATES ARMY.




MEMORIAL TO JAMES DEWAR

RECENTLY UNVEILED IN THE ROYAL INSTITUTION, LONDON, WHERE DEWAR CARRIED ON HIS IMPORTANT CHEMICAL WORK, INCLUDING THE LIQUEFACTION OF GASES.

*Wide World Photos.*

BUST OF LUTHER BURBANK

TO BE DEDICATED TO HIS MEMORY AT SANTA ROSA, CALIFORNIA, WHERE HE CONDUCTED HIS WORK ON THE CREATION OF NEW TYPES OF PLANTS. THE SCULPTOR SHOWN IN THE PHOTOGRAPH IS MR. ROGER NOBLE BURNHAM, OF LOS ANGELES.

servatory, of which Dr. Schlesinger is director, has recently issued a catalogue giving the motions across the sky of over 8,000 faint stars in a section of the northern sky. Studies of these motions have shown that stars separated by great distances are, in many cases, moving at the same speed and in the same direction. Though it will be necessary to find out how rapidly these stars are moving towards or away from the earth before it can be determined whether they are actually moving in parallel paths, such cases occur so often that they can not be due to chance.

CAN the ambition of children to "grow up" faster, and of all of us to be big and tall, ever be realized by a future generation? Perhaps, if human beings can learn the trick that seems to have been mastered by rats in the laboratory of Dr. Thomas B. Osborne and Dr. Lafayette B. Mendel at the Connecticut Agricultural Experiment Station. A breeding stock of experimental animals under their observation has "speeded up" the growing process by nearly a third during the past half-generation. In the course of the past fifteen or more years they have had the opportunity to secure records of the

rate of growth of several thousand rats under controllable conditions with respect to diet and environment. The animals have been bred from laboratory stock without any introduction of "new blood" within the past ten years. The stock diet during this period has presumably remained essentially the same so that changes in the average rate of growth may perhaps be properly attributable to the effects of selective breeding in the attempt to secure vigorous animals for experimental use. A noticeable increase in the average rate of growth has in fact resulted. For example, the average time required by male rats to grow from two ounces to seven ounces body weight has gradually decreased; it was approximately 94 days in 1912; 89 days in 1913; 70 days in 1919, and 67 days in 1925.

THOUGH a baby, or a small boy, may "grow like a weed," his growth does not go on at a steady, unvarying rate, but in three grand spurts, which overlap each other, making the "growth curve" which scientists plot to measure the rate into a very complex affair. Dr. Charles B. Davenport, of the Carnegie Institution of Washington, spoke of his studies of this problem. The first period of maximum growth rate is at the time of birth. The baby grows fast, as everybody knows, but the rate of growth falls off for several years. Then it starts to speed up again and, in the case of boys, at least, it reaches a climax at about eight years—that embarrassing time when a boy's knees simply will not stay inside their proper garments. A second slowing-down follows, and then a second speeding up, the rate of growth reaching its maximum at fifteen—the "all hands and feet" period, when the youth is "shooting out of his shoes." The three growth-spurts correspond closely with periods of greatest activity of some of the internal glands. The first and second periods of growth correspond with activity on the part of thyroid and pituitary glands, respectively, whose secretions are known to be growth-promoting. The third cycle is a fundamental one, underlying the others, and probably represents some more general growth stimulus exerted from the time of the first existence of life until growth stops altogether.

A METHOD of complete denervation of the heart of an animal which has facilitated study of the effect of emotions on the body was described by Dr. Walter B. Cannon and Dr. S. W. Britton, of the Harvard Medical School. The method of cutting off the heart from the nervous system leaves the adrenal glands, which play so important a part in emotions, as the only glands affecting the heart action. When fear or anger is aroused, the adrenals secrete adrenin, which makes the heart beat faster and speeds up the body mechanism, so that there is more energy for fighting or for escape. It was previously known that the denervated heart is extraordinarily sensitive to adrenin. Such a heart would beat faster when adrenin was present in the blood circulating through it in the ratio of one part in more than a billion. By their method, the two physiologists found that even if the animal changed from lying down to walking, the heart rate increased 10 to 15 beats a minute. Emotional excitement without much muscular activity increased the rate about 20 beats a minute. And in aggressive rage, when there was great muscular stress, the heart was sometimes accelerated as much as 70 or 80 beats per minute.

THE living tissue of plants sometimes responds to the stimulus of disease, not by producing the characteristic diseased growths, but by producing normal kinds of tissue in the wrong place, according to Dr. Erwin F. Smith, of the U. S. Department of Agriculture. Dr. Smith,

*Wide World Photos.*

LIEUTENANT-COMMANDER R. E. BYRD, U. S. N.

AT THE SEXTANT OF THE GIANT FOKKER AIRPLANE IN WHICH HE REACHED THE NORTH POLE.

who is an authority on the crown-gall disease of plants, injected some of the organisms that cause this malady into sunflowers. They responded by growing extra rays, or petals, in the disk of the sunflower head instead of around the edge, by forming cavities within the plant, lined with the hair cells normally found on the outside, and by forming woody tissues in the pith, where normally nothing of this kind is found. Dr. Smith points out these phenomena as striking examples of the effects upon young growing tissue of changes in environment; semi-mature tissue, he says, does not show such effects.

WHEN drops of blood are cultivated outside the body some of the white blood cells, which normally act as guards against germs, undergo considerable change. Dr. Warren H. Lewis, of the Johns Hopkins University and the Carnegie Institution, in his paper said some of these mononuclear cells develop into macrophages, the wandering cells of the body that combat disease, while others become epithelioid cells similar to those in tuberculous lesions. Mononuclear blood cells probably undergo similar changes in the body. The tumor cell in one variety of rat sarcoma has been found to be a modified mononuclear white blood cell of the epithelioid type. Pure cultures of such tumor cells inoculated into a rat produce tumor, and cultures from the tumor so produced behave like that of the original.

CAPTAIN ROALD AMUNDSEN

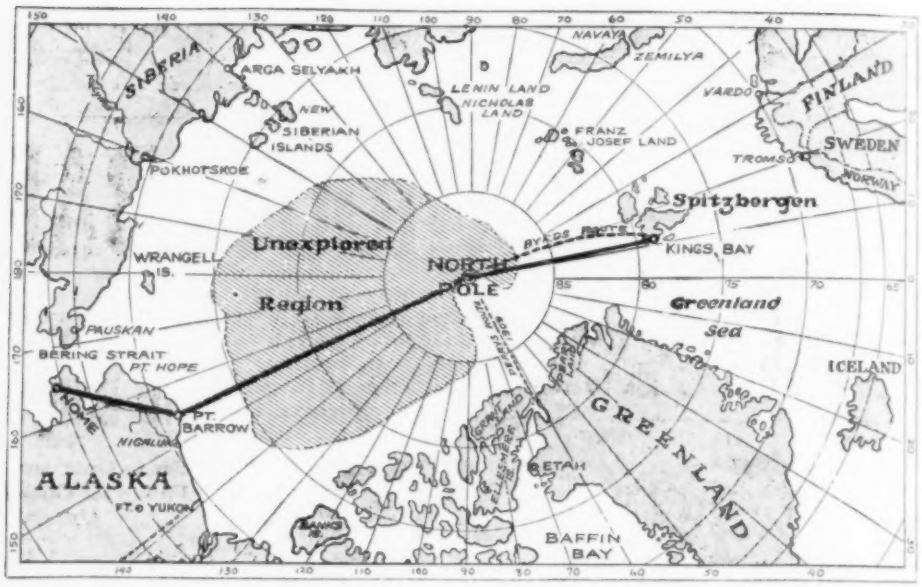
*Copyright, P. & A. Photo.*

THE NORGE AT OSLO

THE "NORGE I," MOORED TO THE MAST AT EKEBERG, OSLO, THE AIRSHIP OF THE AMUNDSEN-ELLSWORTH EXPEDITION TO THE NORTH POLE.

AN effort to determine the fundamental differences between sexes has been made by studying bread moulds. This group of fungi has distinctly sexual type of reproduction, but on account of the similarity in appearance of the sexes it has been impossible to tell clearly which was male and which was female. Since the sex cells are equal in size and the developing offspring are apparently nourished equally by both sexes these fungi are especially suited for study of this problem, according to the paper by Dr. Albert F. Blakeslee, of the Carnegie Station for Experimental Evolution. Investigations carried on by him and Miss Sophia Satina at the Genetics Laboratory at Cold Spring Harbor show that the females of the higher plants make a more active response to biochemical tests than males. The biochemical test to determine sex in man, made by mixing certain reagents with the blood, has been found applicable to plants, and over 90 per cent. of correct sex identifications have been made by this method. The bread moulds have been found to react chemically to these tests in the same way as do the higher plants and animals, thus enabling us to ascertain which are male and which are female.

How nitrogen can be changed to fluorine and then to hydrogen and oxygen when hit by the rapidly moving nucleus of an atom of helium was de-




*Courtesy of the New York Times.*

THE NORTH POLAR REGIONS

THE DOTTED LINE SHOWS THE COURSE FOLLOWED BY LIEUTENANT-COMMANDER BYRD TO THE POLE. THE HEAVY BLACK LINE SHOWS THE COURSE FOLLOWED BY THE NORGE TO THE POLE AND THE PROPOSED COURSE FROM THE POLE TO NOME.

scribed by Dr. William D. Harkins, of the University of Chicago, who has succeeded in photographing the changes. In a closed chamber containing very moist air, the moving atoms are not visible, but they have the property of condensing the water vapor along their path into a long narrow cloud, so that their path can be traced and when one atom hits another, a forked line is seen, due to the fact that they rebound. This process was invented by Professor C. T. R. Wilson, of Cambridge University, England. A photograph taken by this method indicates that a fast helium nucleus strikes the nucleus of a nitrogen atom, possibly forming the nucleus of a fluorine atom. This almost immediately explodes to give a fast hydrogen nucleus and the nucleus of an oxygen atom. Efforts to convert mercury to gold were unsuccessful. An X-ray tube was used to shoot electrons at 138,000 to 145,000 volts into mercury. If any one of these electrons were to add itself to the nucleus of a mercury atom, without driving out another particle, an atom of gold would be formed. If any electrons attach themselves in such a way, less than one in a billion does so, since no trace of gold was found in the mercury bombarded.

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# CARL ZEISS
## Prism Binoculars

OBJECTS in motion are quickly spotted through a Zeiss Prism Binocular. The circles in the picture show the areas of view with different glasses, but all having the same magnification. The center field No. 1 is all you see with a non-prismatic glass. The inner circle No. 2 shows the view with a prism field glass and the outer circle No. 3 the full field of view that is possible only with a Zeiss wide-angle Prism Binocular.

A ZEISS glass, not requiring constant centering upon a moving object, such as birds in flight and game on the run, offers certain distinct advantages. Moreover, Zeiss Field Glasses are dust and moisture proof, a factor of especial appeal to the active outdoor man. Hence, naturalists and scientists continue to specify Zeiss as their standard equipment.

*Write for interesting catalogue, listing 22 models, ranging from 3 to 18 power.*

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**New York**

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Tested

# Brewers' Yeast-Harris

## Medicinal

Brewers' yeast, *Saccharomyces Cerevisiae*, freshly removed from the fermentation of beer or ale. Washed and pressed to remove water-soluble foreign matter associated with the yeast during fermentation.

Dried in a high vacuum, at low temperature and finely pulverized.

Proven for its Vitamine-B value by feeding daily, weighed portions to young, growing white rats and measuring the effect upon the appetite and the increase in body weight.

Conn. Experiment Station, Bul. 240, shows this yeast to be superior to bakers' yeast as a source of Vitamin-B.

Published reports in 1925 have shown this yeast to be superior to the bread-raising variety as a cure for pellagra.

**Important in Pellagra**

Drs. Goldberg and Tanner, U. S. P. H. Service, have published, "Public Health Reports, Jan., 1925," their results with Brewers' Yeast-Harris in pellagra cases, in Georgia.

In describing their curative results with 26 cases of pellagra, they advise ½ oz. to 1 oz. Brewers' Yeast-Harris, daily, mixed with any part of the food, as desired. That is about 2 or 3 teaspoonfuls daily.

*Keeps indefinitely*, in a dark, dry, cool place.

*Yeast is a food; an overdose is impossible.*

Prepared by

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